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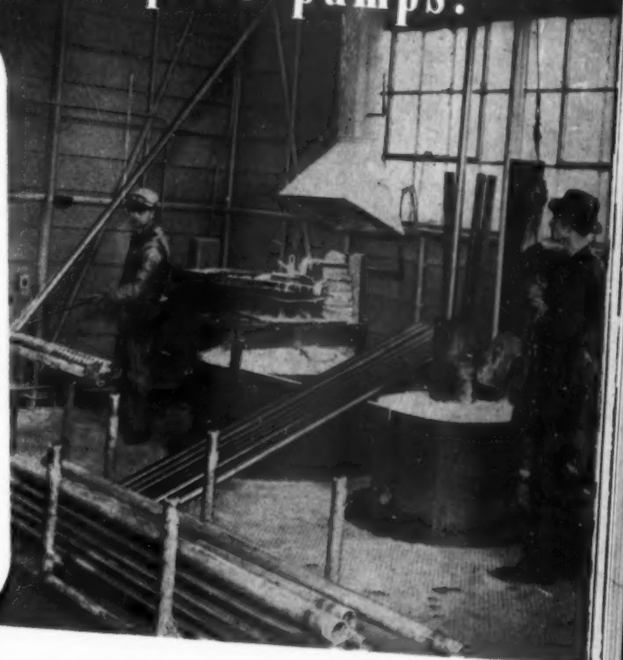

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THE Petroleum Engineer

VOL. XIII No. 6

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Clarence Morris, President, 1929-40

A Magazine of Methods for Operating Men

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CONTENTS

DRILLING AND PRODUCTION — Page

Directional Drilling Deflects Hole into Productive Zone — 31
By C. C. PRYOR

The Question of Petroleum Reserves — 33
By PRENTISS T. MOORE

Orientation of Conventionally Recovered Cores — 46
By WALLACE A. SAWDON

Use of Meters for Measuring Production from Individual Wells — 60
By WALLACE A. SAWDON

Gathering System Designed for Gravity Flow in New Michigan Field — 152
By J. C. ALBRIGHT

So, You Want to be a Petroleum Engineer? (Part 3) — 156
By LESTER C. UREN

REFINING AND NATURAL GASOLINE MANUFACTURE

Economics of the Alkylation Process in the Production of High-Octane Gasoline — 27
By R. G. LOVELL

Refinery Practice for the Operating Man (Vocational Class Proceedings in Refinery Engineering) — 38

Cycling Plant Converted from Refrigeration to Absorption Process — 50
By C. C. PRYOR

SPECIAL PIPE LINE SECTION

Electrical Protection and Use of Light-Weight Pipe in Pipe-Line Construction — 71
By WALTER F. ROGERS

"Blueprint" for Conserving Time and Materials in Pipe-Line Systems — 76
By H. E. DRALLE

Eliminating Hydrate Formation in South Texas — 83
By FRANK H. DOTTERWEICH

Modern Equipment Facilitates Construction of Pipe Lines — 90
By L. H. FAVROT

Cathodic Protection Installation Carefully Engineered — 99
By CHAS. F. OFNER

Co-ordinating Electric Pipe-Line Pumping Equipment — 104
By W. G. TAYLOR

War Requirements Bring Changes in Arc-Welding Technique — 114
By C. M. TAYLOR

Oxy-Acetylene Flame-Priming of Line Pipe — 120
By F. C. HUTCHISON

Pipe-Lines—Their Construction and Operation — 124
By G. A. PALMER

Coating and Wrapping Pipe by Machine — 131
By W. H. T. THORNHILL

Unavailable Compressor Parts Fabricated by Pipe-Line Employees — 134
By M. M. HELLER

Handling Pipe in the Central Yard — 137
By FRANK H. LOVE

Communication and Signaling Features on New Line — 140
By L. E. ADLER

GENERAL

Solving Carbon Dioxide Problem of Boiler Flue Gas — 36
By W. F. SCHAPHORST

Supplemental Order No. 1 to M-68 — 188

Amendment No. 3 to Order M-68 — 188

Countersignature of A-8 and Lower Under P-98 Waived — 188

Amendment No. 1 to Order No. P-98 — 188

ENGINEERING NEWS OF INTEREST

U. S. Bureau of Mines Research on Operating Phases of Petroleum Industry — 30

U. S. Bureau of Mines Reports on Study of Hydrates in Gas Lines — 144

PICTORIAL SECTION — 147

REGULAR FEATURES

The Course of Oil — 14
Highlights in Oildom — 16
Major Refining Activities — 18
Major Oil Field Activities — 20
Petroleum Statistics and Field Activities — 22
Major Pipe Line Activities — 24
The Petroleum Engineer's Continuous Tables (Installment No. 57) — 167
Running Tour With Men in the Industry — 183 and 184
Laugh With Barney — 186
From Washington — 188
Machinery and Equipment — 192, 194, 195, 196, 197, and 198
Book Reviews — 209
Trade Literature — 210 and 211
Meetings — 213

MEMBER A. B. C.—A. B. P. (The articles in *The Petroleum Engineer* are indexed in the *Industrial Arts Index*, New York, N. Y.)

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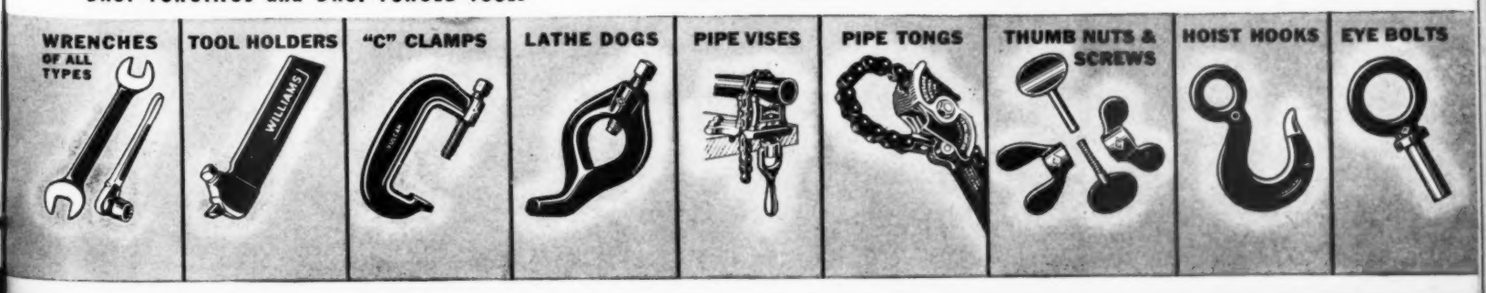

The Course of Oil

by K. C. SCLATER

FACING REALITIES

Loss of the oilfields and refineries of the East Indies has become a stark reality. Burma's oil resources are dangerously close to falling into enemy hands. Soon we may witness an attempt by enemy forces to invade the oilfields and refineries of the Near East, including the vast oil riches of the Caucasus. These may not be captured, but as a source of supply for the Allied Nations they may be rendered useless for immediate war needs. Should this happen or should any one of the Near East oilfields fall into enemy hands, the war will be prolonged, perhaps for years. That will mean almost complete dependence by the Allied nations on United States oil for prosecution of the war. Long-range planning will then become imperative for supplying on a world-wide scale needed petroleum products to all the Allied Nations.

Close as we are to facing these realities, the drilling branch of the industry is still in a lull and involved in a maze of restrictions instead of girding itself for the unpredictable demands of the immediate future. More liberal regulation is needed in the industry so it can utilize all its available facilities and engage in a concerted drive to increase the nation's oil reserves.

Conservation of critical materials is one thing, but the prudent utilization of available equipment is another. It has been roughly estimated that there are about four thousand strings of rotary drilling tools in the country and some three thousand strings of cable tools. In normal times seventy-five percent of these are in operation, but owing to current restrictions it is estimated that now less than half of the available drilling equipment is in operation. In other words, fifty percent of the drilling equipment is lying idle, this at a time when the discovery of new oil reserves is lagging. If this equipment were in use, the gross consumption of steel actually used in drilling would not be so very great. Casing for wells would be permanently used-up only in holes in which oil was discovered.

More liberal drilling regulations and less restrictions would be of substantial aid in speeding-up the search for new oil reserves. Our failure to look far enough ahead now and make ample provisions for meeting war contingencies may lead to reckless haste and consequent dissipation of effort and resources later on. The present lull in drilling as a result of restrictions has cost many drilling contractors a loss of personnel, a loss that can only be regarded as a serious economic one, the effects of which are likely to be felt should the necessity for an intensive drilling program be forced upon the oil industry, as it surely must.

DEPLETION ALLOWANCE

A disturbing and harassing factor also is the Treasury Department's request for removal of the percentage depletion allowance in the tax laws. No more inopportune request could have been made. It is one that has created a feeling of futility among operators, many of whom are beginning to ask themselves whether oil is really important. The effect on the industry has been an unwholesome one that could have far-reaching, harmful results. Many small operators and most of the larger ones are operating on a margin of profit so thin that were the depletion percentage allowance discontinued they could not carry on. Many wells would have to be abandoned and the production therefrom lost to the nation. In the face of rising costs many operators have had to forego a justified increase in crude prices, and so have been compelled to effect what savings they could by improving the efficiency of their operations to offset rising costs. They are now confronted with a shortage in critical materials and also labor, so deletion of the percentage depletion allowance would be tantamount to a flat reduction in revenue. It would cut short the economic life of many producing leases and result in premature abandonment of a vast number of wells. Considering the gravity of the world situation and the paramount importance of petroleum with respect thereto, raising the question regarding depletion allowance at this time is an ill-considered action.

TANKER LOSSES

Coastwise tanker transportation losses have become serious. An indirect result is the crippling of domestic producing operations. Lack of storage and pipe line facilities in some areas has forcibly demonstrated to the authorities the seriousness of the dislocations in field operations that can ensue.

According to information from Washington, the construction of a line from the Gulf Coast to the Atlantic Seaboard is out of the question because of the shortage of steel. It is just about a year ago that such a pipe line was given serious consideration as a national defense project. There was no doubt even then of the necessity and desirability of the pipe line in war, but ostensibly the issue was that of the more pressing need of steel for other purposes.

Consider what has happened. An alarming amount of steel tanker tonnage has been sunk, an amount that would have been almost enough to build the pipe line. The tonnage sunk might have been less had pipe line transportation facilities been available; how much less no one can say. Had the tankers been in operation in shipping lanes other than in the coastwise shiplanes of the United States they might have been less vulnerable to attack. Tanker sinkings of the magnitude suffered were certainly not foreseen a year ago, though they were not entirely unexpected. The lesson taught by this experience should not be lost—even at this late date.

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Highlights IN OILDOM

Refiners Reduced Intrastate Oil Receipts in 1941

For a period embracing the last eight years petroleum refineries have been taking more crude oil from the states in which they are situated than from other states; however, this trend was reversed in 1941, a report by the U. S. Bureau of Mines shows.

Since 1934 the volume of intrastate crude oil, that is, oil produced in the same state in which the refinery receiving it is situated, has increased 65 percent, whereas interstate receipts have gained only 48 percent. Compared with 1940, however, the 1941 intrastate receipts increased only 6 percent, and interstate receipts 11.7 percent.

Total refinery receipts of crude oil produced in the United States was 1,359,826,000 bbl. in 1941, a gain of 8.2 percent over 1940. Intrastate receipts totaled 815,345,000 bbl., or 60 percent of the total. Oil-producing states shipped 544,481,000 bbl. of crude oil to refineries in other states.

Refineries in the United States processed 1,409,192,000 bbl. of crude oil in 1941, and consumed 2,369,000 bbl. as fuel and losses. The difference between this total and the 1,359,826,000 bbl. of domestic crude oil received was made up by imports of crude oil from Mexico and South America, and by a small draft on refinery-held crude oil stocks, which declined 1,129,000 bbl. during 1941.

Holds Louisiana Law Unconstitutional

The Louisiana gas well spacing and unitization act, insofar as it delegates to the Conservation Commissioner the right to designate drilling units without fixing any base or rule and to enforce pooling of interests in such units, has been held unconstitutional by Civil Judge Nat W. Bond at New Orleans. Judge Bond also held that any attempt by the legislature "to force the pooling of the interests of landowners in a drilling unit, particularly where a well has been drilled and completed as a producer and a market has been established for said gas, is unauthorized taking of property without due process of law."

The decision enjoined Conservation Commissioner Joseph L. McHugh from requiring Hunter Oil Company, Inc., to unitize into a 320-acre block a 190-acre tract on which the company has a producing gas well in the Logansport field, De Soto Parish. The jurist held additionally that spacing regulations for the field are unconstitutional.

"The ruling if upheld by the highest court," commented Edward L. Gladney, Jr., counsel for the Conservation Department, "will knock out the spacing regulations and unitization of producing tracts throughout the state."

Seek to Substantiate Depletion Allowance

Preparations are being made by the California oil industry, in collaboration with the oil industry in other states, to substantiate the present statutory depletion allowance in computation of income taxes, now the object of attack by the treasury department, according to a statement by the Oil Producers Agency of California.

A State "depletion" committee, composed of representatives of the California Oil and Gas Association, the San Joaquin Valley Oil Producers Association, the California Stripper Well Association, and Oil Producers Agency, has been organized and will begin immediate development of factual material, policies, and methods intended to demonstrate to the treasury department that the depletion allowance is a necessity for the oil industry and other natural resource industries, and not a tax "loop hole." Work of this State committee will be coördinated with that of similar committees in other oil producing states through a national depletion committee in Washington.

"The depletion allowance, by permitting oil companies to recover the capital expended in the industry's drilling and exploration activities, is an important factor in the discovery of additional oil reserves needed to replace present production and carry on the war," according to C. P. Watson, Oil Producers Agency representative on the State Committee. "A sub-committee of the Petroleum War Council, appointed at the request of Petroleum Coördinator Ickes to study ways and means of increasing oil reserves and preventing abandonment of small wells, found that the depletion allowance not only enabled the industry to continue its exploration activities and thus locate new reserves, but also that it enabled operators of marginal wells to keep them on production and thereby maintain the continuity of their output for war purposes. The sub-committee report suggested that it would be wiser governmental policy at this time to increase, rather than decrease or eliminate, the allowance. The report was approved by the War Council, and was also approved by Coördinator Ickes."

Reclassification of Field Denied

Efforts of several large leaseholders to have the Tri-Cities field near Malakoff, Henderson County, Texas, reclassified from an oil field to distillate field have met with failure, the Texas Railroad Commission refusing to make the change. The decision means that the field will be developed on a 40-acre basis instead of the 640-acre units as allowed for a distillate field. There has been no activity in the field since the discovery well, British American Oil Producing Company Young No. 1, was brought in last November.

Ickes Says Oklahoma Drawing Too Heavily on Reserves

In a letter to the State Corporation Commission, Petroleum Coördinator Ickes stated that Oklahoma is drawing too heavily upon its oil reserves and asked for an increase in wildcatting to seek new fields. He asserted that only Illinois among the nine principal petroleum producing states is making heavier demands on its known reserves.

Ickes said in his letter he would continue to urge "a greater amount of wildcat drilling to offset steadily increasing withdrawals from known pools that must be made during the war, no matter how long it lasts."

The coördinator assured the commission that no limit would be placed on stripper and secondary production except in unusual circumstances.

Take Added Protection Measures

Protection of California oil fields, refineries, storage facilities, loading terminals, and pipe-line transportation systems has been consolidated under the Oil Industry Protection Committee, of which A. C. Rubel, vice-president of the Union Oil Company, is chairman, and of which George F. Prussing is engineer in charge.

The committee, composed of members representing various interests in the industry and various geographical locations in the state, is the outgrowth of the Oil Field Protection Committee, which was organized early in December to develop means of protecting oil fields, and of a committee formed by the American Petroleum Institute to develop protection of storage, refining, loading, and transportation facilities.

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Percent Refining Capacity Operated

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THE Girdler Corporation of Louisville, Kentucky, is proceeding with the design and erection of a Girbotol plant to purify and dehydrate 25,000,000 cu. ft. per day of condensate-separator gas from the McKamie field, Arkansas, for the McKamie Gas Cleaning Company of Arkansas. This is the first purification plant designed to produce a marketable gas from this extremely sour field.

The gas, which contains about 4500 grains of hydrogen sulphide per 100 cu. ft. and approximately 5 percent carbon dioxide, will be purified to pass the very sensitive U. S. Bureau of Standards test for hydrogen sulphide. Incidental removal of carbon dioxide will increase the heating value of the gas. The dehydration feature has been added to prevent hydrate formation in the transmission system. The plant will be complete including steam and cooling water facilities.

A gasoline recovery plant will be erected along with the purification plant and later it is planned to add another plant to convert the recovered hydrogen sulphide to elemental sulphur, sulphuric acid, or some other useful product.

A Fort Worth, Texas, oilman, Neville G. Penrose, has advocated the building of a large refinery by the government in the West Texas-New Mexico Permian Basin because it could be "the one invulnerable refinery in the world."

"We have the greatest known oil reserve in the world without an adequate market," Penrose stated. "We are swimming in a sea of oil, while less than 2000 miles away on the Atlantic Coast, they are in need of what we practically are drowning in and can't dispose of." Penrose estimated that there are from six to ten billion barrels of known oil reserves in the Permian Basin within 150 miles of Hobbs, New Mexico.

Construction of an aviation gasoline refining plant in the Cromwell field, Oklahoma, at an estimated cost of $300,000 has been announced by the Shell Oil Company, Inc. The plant will be situated in the heart of an area where company holdings are considerable.

Present plans are for the plant to produce high-octane aviation fuel for use in planes. According to officials of the company, the demand for high-octane fuel in recent months and the prospect of increasingly heavy demands as the war continues will justify construction of the plant.

Construction has already begun on a pipe line from wells in the Cromwell field to the projected plant. Company officials were unable to say when it would be completed due to the uncertainty of obtaining materials.

Refinery owners and operators at a recent meeting in Gladewater, Texas, were told that the government "is willing" to spend $10,000,000 in the East Texas area to produce high-octane aviation gasoline and components of synthetic rubber.

An engineering survey has been launched to determine whether East Texas crude oil meets the requirements and whether a sufficient quantity of the crude could be provided.

Representatives of the seven operating refineries in East Texas attended the meeting called by J. O. Newberry and Loyce Phillips, manager and president, respectively, of the Gladewater Chamber of Commerce.

Newberry reported that he and Phillips had been advised that the government would finance a "central plant" at a cost of $10,000,000 if the refineries met two stipulations:

1. Plans and specifications for a plant, with estimates of the necessary investment and production costs and descriptions of machinery and processes would have to be submitted.
2. A minimum of 15,000 gal. of reduced crude oil, obtained from regular crude oil, would have to be provided.

Newberry stated that a prime consideration was that the refineries "get together" and submit the proposition jointly.

A motion by J. B. Cashell of the Lynch and Lacy Refinery, Kilgore, resulted in the nomination of a four-man committee to contact an engineering firm and learn what plant facilities would be required.

Elected on the engineering committee were T. A. Bath of the Independent Refining Company, Henderson, Texas; J. D. Wadell, Skelly Oil Company, Longview, Texas, and H. F. Richardson and C. E. Wharton, Gladewater Refining Committee.

The Standard Oil Company of Indiana has concluded a contract with the government to build and operate a toluene plant in connection with its refinery at Whiting, Indiana. Production of the one plant would equal the total annual output of toluene in the United States in World War I.

The company is now concerned with negotiations with the government to construct an alkylation and butane isomerization plant at Whiting to increase its output of 100-octane aviation fuel. The existing facilities at the refinery are already operating at capacity and are supplying large amounts of aviation gasoline.

An allocation of $3,225,000 has been made to The Premier Refining Company of Longview, Texas, to construct and operate an essential defense plant in southwestern Arkansas. It has been reported that it will process and make usable considerable sour gas.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended February 28, 1942
A.P.I. Figures

(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	565	79.1	19,027	15,773
Appalachian	84.5	157	90.2	3,719	964
Ind., Ill., Ky.	84.9	692	88.3	22,548	7,051
Okla., Kans., Mo.	81.1	342	81.8	10,474	2,873
Inland Texas	65.0	184	69.2	3,604	1,283
Texas Gulf	91.3	883	78.1	20,688	17,943
Louisiana Gulf	94.9	158	89.8	4,675	3,845
No. La. & Arkansas	51.5	83	85.6	1,212	384
Rocky Mountain	50.7	82	59.4	2,417	920
California	90.9	529	67.2	17,271	72,796
TOTAL U.S.-B. of M. Basis Feb. 28, 1942	86.9	3,675	78.5	(a)105,635	123,832
TOTAL U.S.-B. of M. Basis Feb. 21, 1942	86.9	3,889	83.0	104,312	124,597
U. S. B. of M. Basis March 1, 1941		3,561		95,646	130,820

(a) Finished 97,132,000 bbl.; unfinished 8,503,000 bbl.

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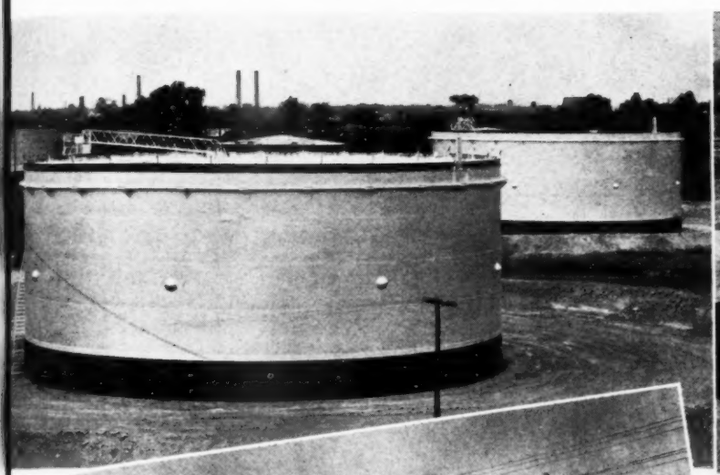
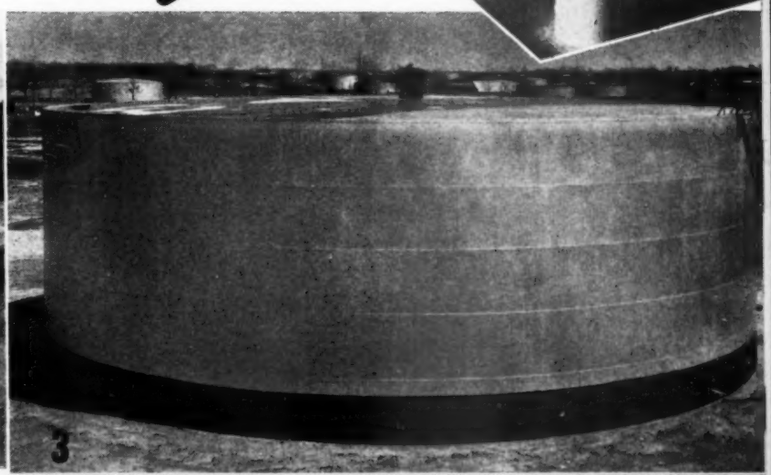
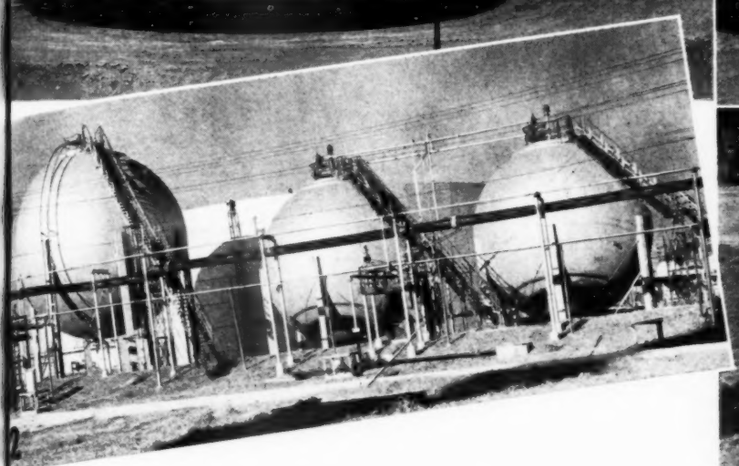
Aerial view of 13 Wiggins Pontoon Roof tanks at a pipe line terminal. Capacities range from 10,000 to 55,000 barrels.







OIL companies operating modern pipe line systems and bulk plants have found it increasingly profitable to utilize equipment and methods that emphasize conservation. Because they are specifically designed to prevent evaporation losses, Horton oil storage tanks have figured prominently in this move toward greater efficiency. Today, in the Horton line, you can find modern steel tanks for each type of service—enabling you to use the right tank for the job. These include tanks with Wiggins Pontoon, Breather and Balloon Roofs, Hortonspheroids, and Hortonspheres.

Several examples of the way in which some of this equipment is used at pipe line terminals, bulk plants and pumping stations are illustrated here. For complete information or quotations on units to meet your requirements, please write our nearest office.

(1) Two of three 55,000-bbl. Wiggins Pontoon Roof tanks installed at the Lima, Ohio, station of the Buckeye Pipe Line Co. (2) One 5,000-bbl. and two 2,500-bbl. Hortonspheres used to store butane received by pipe line. (3) One of four 80,000-bbl. Wiggins Breather Roof tanks at the Shell Pipe Line station, Lima, Ohio. (4) 25,000-bbl. Wiggins Balloon Roof tank storing gasoline at an Illinois bulk station.

CHICAGO BRIDGE & IRON COMPANY

HOUSTON . . . . . 5637 Clinton Drive	CHICAGO . . . . 2481 McCormick Bldg.	NEW YORK . . 3373-165 Broadway Bldg.
TULSA . . . . . 1634 Hunt Bldg.	CLEVELAND . . 2251 Builder's Exchange	WASHINGTON . . 632 Washington Bldg.
BIRMINGHAM . . . . 1570 N. 50th Street	PHILADELPHIA . . 1635-1700 Walnut St.	SAN FRANCISCO . . . 1064 Rialto Bldg.

Fabricating Plants in BIRMINGHAM, CHICAGO and GREENVILLE, PA.

MAJOR *Oil Field* ACTIVITIES

SEABOARD Oil Company apparently has discovered a new oil pool in Franklin County, Illinois, with its well, U. S. Coal and Coke Company No. 1, C SW SE, 14-6s-4e, which found saturated Weiler sand from 2840-50 ft. and recovered 200 ft. of oil and 100 ft. of oil-cut mud on a drill-stem test with tool open one hour. This well is located about 5 miles west of nearest production in the Rural Hill pool. The well cored ahead from 2850 ft. to 2855 ft. and recovered 5 ft. of saturated sand with a salty taste. The second drill-stem test, with the tool open for 45 minutes, filled 290 ft. with fluid, 50 percent oil and 50 percent oil-cut mud without water.

A Pottawatomie County, Oklahoma, wildcat well has found production of natural gas estimated at between 5,000,000 and 10,000,000 cu. ft. on a 10-minute drill-stem test. The well, C. W. Sharp No. 1, NE SE SE of 1-9-2, found gas in the Simpson Dolomite between 5575-87 ft. An oil showing was found in the mud when the drill-stem was pulled. The test is to be drilled to the Wilcox sand.

Cameron Brothers, Landwehr No. 1, 8-5n-7e, Clay County, Illinois, has opened a new McClosky lime pool. The well flowed 460 bbl. of oil the first 12 hours and 300 bbl. the second 12 hours from a total depth of 2825 ft. Nearest production from the well is about 8 miles.

Humble Oil and Refining Company, Petit Anse Company No. 1, section 25-13s-5e, has indicated possible discovery of a new oil pool on the southwest flank of the Avery Island dome, Iberia Parish, Louisiana. The wildcat well was drilled to 7000 ft. and the operator has plugged-back to 6470 ft. and set casing for a series of tests. It has been reported that the well encountered a heavy gas pressure around 6300 ft.

The company has opened new deep sand production in the Potash dome field, Plaquemines Parish, Louisiana, with the completion of Orleans Levee Board No. 57. A flow of 35.8 bbl. of 25-gravity oil was obtained on a two-hour gauge from 8707-40 ft. Tubing pressure was 1100 lb. with gas-oil ratio 410 to 1.

A southern Cass County, Texas, wildcat has been brought in to flow 25 bbl. per hour to open a new oil field along the Rodessa fault system. The well is owned by John Messenger, Marshall, Texas, operator. It is Benefield and Singleton No. 1, James Wanhop Survey, and is located more than 3 miles northwest from the nearest production at Lodi in the Marion County part of the Rodessa field. Natural flow resulted after the casing had been perforated from 5992-6010 ft. with 45 shots in the Gloyd zone, second Rodessa pay section. The well was turned into tanks and made 25 bbl. per hour through ⅜-in. choke under pressure of 850 lb. on the casing and 300 lb. on the tubing. Gas volume of the well was estimated at 350,000 cu. ft. per day. Gravity of the oil, green in color, is 40.39 and gas-oil ratio is 1343 to 1.

The Gloyd zone was topped at 5993 ft., total depth of the well is 6205 ft., 5½-in. casing was set to 6100 ft. to test the Dees section, third Rodessa pay topped at 6153 ft., that indicated water. Commission gauge was reported as 210 bbl. per day through ¼-in. choke.

AVERAGE CRUDE OIL PRICES

California	
Kettleman Hills	$1.23-1.29
Playa Del Rey	.80- .87
Coalinga	.73-1.13
Wilmington	.68-1.24
Montana	1.00-1.15
Wyoming	.45-1.15
Colorado	.96-1.20
New Mexico	.70-1.15
Texas	
North Central	.97-1.21
Panhandle	.70-1.12
West Texas	.80-1.27
Gulf Coast	.93-1.48
Darst Creek	1.14
East Texas	.80-1.27
Talco	.79
Kansas	.93-1.25
Oklahoma	.75-1.25
Arkansas	.94-1.36
Louisiana	
Rodessa	.88-1.20
Gulf Coast	.90-1.36
North Louisiana	.98-1.30
Illinois	1.22-1.37
Kentucky	1.32-1.43
Indiana	1.25
Ohio	
Lima	1.17
Michigan	1.24-1.44
Pennsylvania	
Bradford	2.75
Southwest	2.40
Eureka	2.34
Buckeye	2.30
Corning	1.31

DAILY AVERAGE CRUDE OIL PRODUCTION

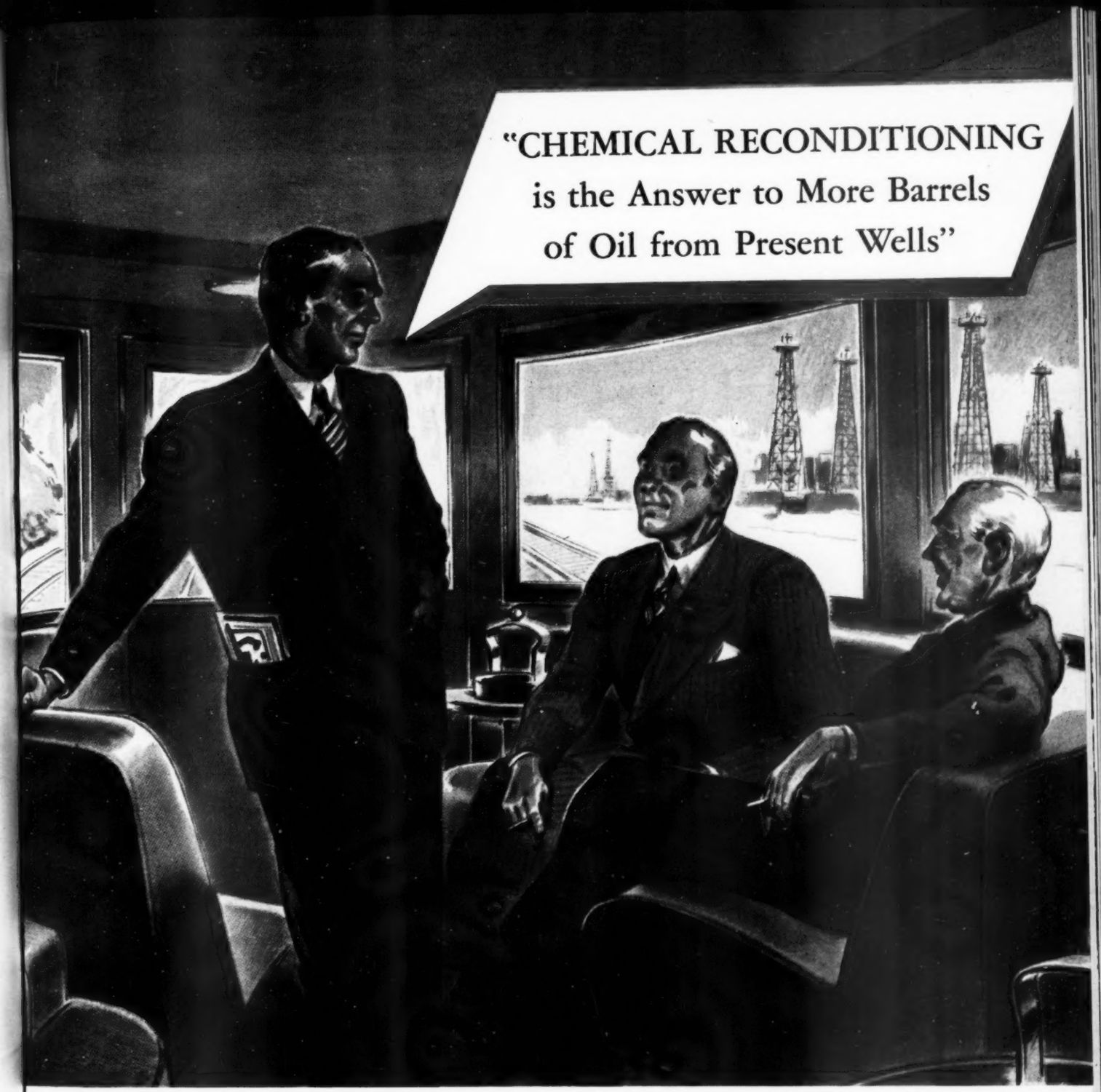
Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]O.P.C. Recommendations for February	Week Ended Feb. 28, 1942	Week Ended Jan. 31, 1942	Week Ended March 1, 1941
Oklahoma	395,300	[2]393,700	408,850	413,250
Kansas	251,700	[2]230,000	251,200	202,550
Nebraska	5,200	[2] 4,450	5,250	4,300
Panhandle Texas	.....	86,700	75,500	68,050
North Texas	.....	148,700	144,350	131,300
West Texas	.....	300,650	242,450	236,100
East Central Texas	.....	91,400	80,000	73,200
East Texas	.....	368,400	291,000	374,600
Southwest Texas	.....	222,900	186,550	205,350
Coastal Texas	.....	296,700	250,150	256,400
TOTAL TEXAS	1,596,000	1,515,450	1,270,000	1,345,000
North Louisiana	.....	81,500	81,000	70,050
Coastal Louisiana	.....	270,600	285,800	222,300
TOTAL LA.	335,000	352,100	366,800	292,350
Arkansas	74,500	73,850	74,500	70,550
Mississippi	57,400	[2] 90,850	79,750	20,400
Illinois	371,800	334,900	370,000	331,150
Indiana	17,200	[2] 19,150	20,750	20,900
Eastern (not incl. Ill. and Ind.)	94,200	95,550	100,800	94,300
Michigan	47,000	50,850	51,300	40,200
Wyoming	78,000	84,400	89,050	81,050
Montana	20,400	21,600	20,800	18,450
Colorado	6,500	5,550	6,650	3,700
New Mexico	119,300	120,400	119,350	104,200
TOTAL EAST OF CALIF.	3,469,500	3,392,800	3,235,050	3,042,350
California	632,300	622,850	636,300	589,900
TOTAL U. S.	4,101,800	4,015,650	3,871,350	3,632,250

[1]These are recommendations of the Office of the Petroleum Coordinator for the month of February.

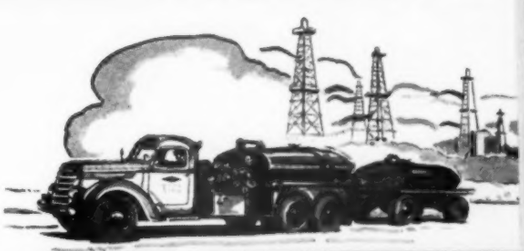
[2]Oklahoma, Kansas, Nebraska, Mississippi, Indiana figures are for week ended 7:00 a. m., February 25.



THERE IS NO QUESTION about the importance of Reconditioning these days. Even during normal times wells were reworked, as a good business practice, to boost production . . . now Reconditioning becomes a subject of much greater prominence.

Today the practice of producing every possible drop of oil has become an economic *necessity*. The bulk of this production must come from present wells—wells that have been *made* to produce more oil through an intelligent Reconditioning program.

Dowell Incorporated has developed and is now offering a program of Chemical Reconditioning Services which conserves manpower, materials and precious time—it is actually producing more barrels of oil.



Look to

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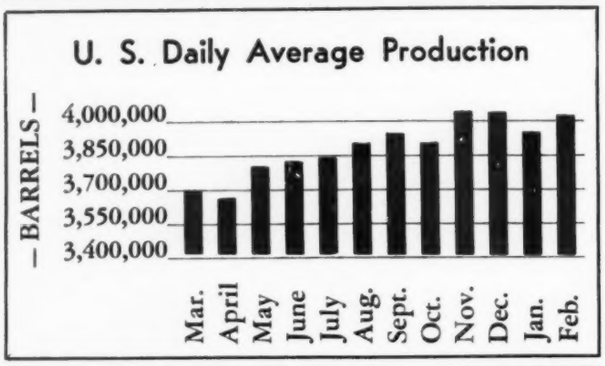
CHEMICAL SERVICE

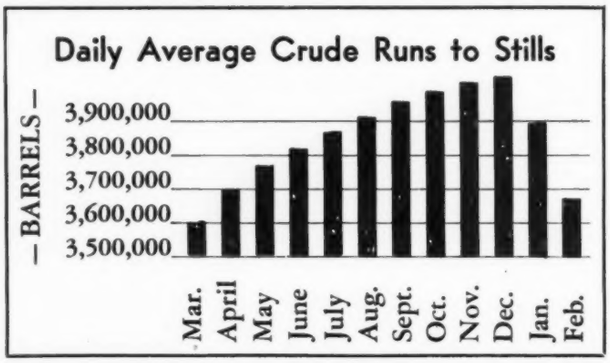
DOWELL INCORPORATED

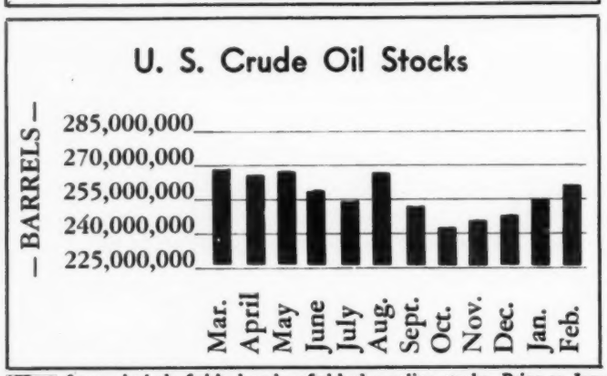
Executive Office: MIDLAND, MICHIGAN — *General Office:* KENNEDY BUILDING, TULSA, OKLAHOMA

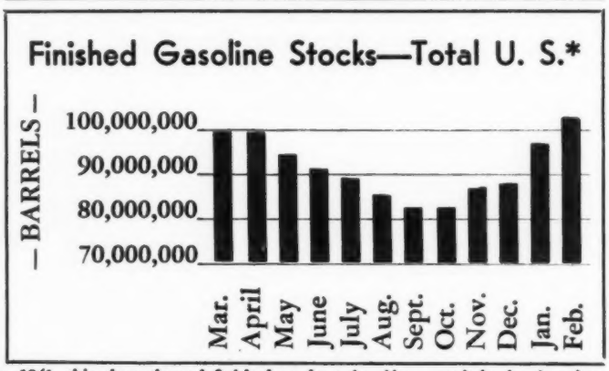
Subsidiary of The Dow Chemical Company

PETROLEUM *Statistics* AND FIELD *Operations*









*These figures include finished and unfinished gasoline stocks. Prior to January, 1941, this chart showed finished stocks only. Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for February, 1942

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	44	27	9	20	3500-3700	2	40	Rotary
Gaines County	3	2	1	5	4400-5584	2	22-35	Rotary
Hockley County	27	24	6	5	4800-6850	2	20-30	Rotary
Ector County	16	13	3	13	3675-4377	2 or 3	32-36	Rotary
Panhandle	58	43	7	16	1700-3900	2	40	Rot.-Cab.
Nueces County	17	17	3	4	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	9	8	2	2	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	18	15	1	2	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	9	6	4	3	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	15	3	4	3	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	12	5	5	6	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	13	4	6	6	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	184	138	198	143	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	18	15	9	7	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	24	22	7	5	1840-11,450	3 or 4	14-30	Rotary
Wilmington	12	10	3	5	3500-4000	2 and 3	18-20	Rotary

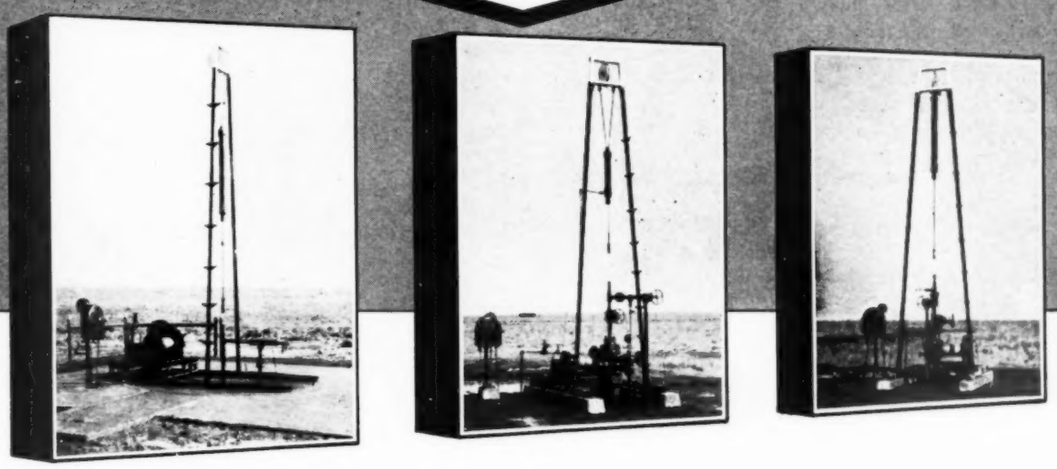
Field Activities by States for February, 1942

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1941 (In Barrels)
	February	January	February	January	February	January	February	January	February	January	
Arkansas	8	5	5	5	6	8	7	6	5	4	29,263,000
California	72	86	63	82	78	75	67	68	43	40	230,271,000
Colorado	2	2	0	1	1	2	1	1	1	1	1,792,000
Illinois	184	257	138	178	175	263	198	277	143	187	131,272,000
Indiana	37	19	22	14	39	36	17	18	32	33	6,998,000
Kansas	121	175	82	123	142	188	27	25	135	142	82,733,000
Kentucky	19	11	7	5	18	20	5	4	12	14	4,790,000
Louisiana	91	93	33	64	94	97	40	38	96	109	116,038,000
Michigan	61	64	35	47	58	90	21	20	49	69	16,312,000
Mississippi	7	20	4	11	....	....	....	....	....	....	15,528,000
Montana	12	11	11	9	7	21	3	7	9	15	7,440,000
Nebraska	1	7	1	4	....	5	....	5	....	4	1,785,000
New Mexico	30	31	23	23	26	28	14	18	25	30	39,109,000
New York	102	101*	102	101*	....	....	....	....	....	....	5,180,000
Ohio	136	109	97	70	....	....	....	....	....	....	3,342,000
Oklahoma	143	177	107	121	170	165	33	22	114	133	154,817,000
Pennsylvania	169	30*	165	26*	....	....	....	....	....	....	16,700,000
Texas	558	705	412	560	630	680	718	750	712	883	501,745,000
West Virginia	79	54	68	47	68	46	30	29	47	70	3,418,000
Wyoming	6	7	4	6	4	8	4	5	3	6	29,952,000
Total	1,838	1,964	1,379	1 497	1,516	1,732	1,185	1,293	1,426	1,740	1,398,485,000

*Includes water-intake and pressure wells.

First line of production economy . . .

NIXON GAS-LIFT



Conservation of men, money and material to achieve ultimate victory is the first responsibility of business today. Nixon Gas Lift is contributing its share to both operators and the nation.

This method of fluid-lifting requires no heavy machinery—no large quantities of vital metals. Its efficient, automatic operation requires minimum personal attention. Use of cheap gas pressure for actual lifting of fluid releases power for other purposes.

All of these advantages establish a fluid-lifting cost that is extremely low. It means economical production—money-saving for you.

Put your wells on the "First line of production economy." Install Nixon Gas-Lift. Write your nearest Wilson Supply Company store or sales office.

The following patents have been issued on the Nixon Surface Control Gas-Lift System: 1,735,025; 2,132,081; 2,136,457; 2,153,770; 2,164,469; 2,171,812; 2,171,478; 2,171,479; 2,171,480; Re 21,199; 2,202,462; 2,204,817; 2,217,072; 2,245,002; 2,245,003; 2,245,004; 2,245,005; 2,245,006; 2,245,007; 2,245,008; 2,245,009; 2,245,010. Other patents pending.

WILSON SUPPLY COMPANY

1412 MAURY STREET — **HOUSTON, TEXAS**

SALES OFFICES: Tulsa, Oklahoma; Dallas, Texas
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MAJOR *Pipe Line* ACTIVITIES

ANNOUNCEMENT has been made by officials of the Phillips Petroleum Company of construction of a 240-mile, 8-in. pipe line from Hobbs, New Mexico, Lea County, via the Wasson and Bennett pools of West Texas, and then due north to Borger, in the Panhandle field of northwest Texas.

It has been reported that word from Washington and the pipe mills indicates that the pipe is of the type used to handle butane and by-products of natural gasoline. Work on the line will begin about April 1 with pipe arriving about the middle of the month. Contract has been awarded by the company to O. E. Dempsey Construction Company.

It is expected that the line will supply the proposed large synthetic rubber plant that it is believed Phillips plans to build with government assistance. No information on the plant has been released regarding size or capacity.

Work has been announced as progressing on the Sinclair pipe line in Eastern Venezuela, South America. The 10-in. line, to extend from the Santa Barbara field, discovered a year ago by the Venezuela Petroleum Company, to Puerta La Cruz on the Caribbean, has been contracted for by Williams Brothers Corporation.

Construction of a road has been completed from the field to the Amama River, over which a bridge is to be built, and from the mesa to the Caribbean terminal. Pipe for the project was ordered and delivered last October.

The Oklahoma Natural Gas Company has announced immediate construction of 100 miles of 12-in. gas line to supply an army camp at Muskogee, Oklahoma. The line will carry gas from the Cement and Chickasha areas in Grady and Caddo counties to a point near Stroud, Oklahoma, on the company's present system. Construction of the line will provide a daily capacity of about 60,000,000 cu. ft.

The War Production Board has refused for the third time to allocate the necessary steel for construction of the large pipe line from Texas to the Eastern Seaboard to alleviate the shortage of gasoline there. The third request for the pipe line was submitted by Petroleum Coördinator Harold L. Ickes.

An increase in capacity has been accomplished by Southern California Gas Company in transmitting gas from the San Joaquin Valley to the southern California area by 20,000,000 cu. ft. per day. To obtain the increased capacity, the company laid 16 miles of 18-in. line from the foot of the Tehachapi Mountains to Grapevine, California, and then northwest to a junction with the pipe lines from the Rio Bravo, Ten Section, and Paloma fields. The new line connects with the 22-in. line at Grapevine that transports gas over the mountains into the Los Angeles, California, area.

Completion of a 204-mile natural gas pipe line running from the Lirette gas field in lower Louisiana to Mobile, Alabama, has been announced by United Gas Pipe Line Company.

The new line supplements the natural gas supply now being delivered in the Mobile-Pensacola area by the existing Jackson-Mobile line. It has been estimated that more than 70 percent of the total capacity of the new line will be used by industries engaged in filling national defense contracts.

Embodied in construction of this line for purposes of economy and speed of construction were some of the most difficult pipelining feats ever accomplished, including the world's longest underwater pipe line, the longest single "shove" ever made, miles upon miles of construction through swampland, numerous river crossings, including a three-line crossing of the Mississippi River.

First notable feat performed on the line was on the Mississippi River 12 miles above New Orleans where a triple-submarine crossing was laid in seven days. The river is 2800 ft. wide at this point and approximately 90 to 120 ft. deep with a very swift current.

The hardest part of the job came when the line was laid across Lake Pontchartrain, 25.59 miles wide at this point. Serious consideration had been given to a land route, skirting the western and northern shores of the lake, but the 25 miles across the lake, as opposed to the 37 miles by land that would have been mostly swamp construction, won out. The lake crossing presented only the problems of the proper use of marine equipment and a gamble with one of the country's most temperamental bodies of water, but represented a considerable saving in steel pipe.

The remainder of the line was laid from Mandeville to Gulfport and then to Mobile through the swamps and rivers of the Gulf Coast.

The Atlantic Pipe Line Company has awarded contract to the Latex Construction Company, Houston, Texas, for 63 miles of 8⅝-in. pipe line from Neale station, east of Maryville, Louisiana, to the Atlantic refinery at Smith's Bluff, Jefferson County, Texas.

The Sunray Oil Company has added 15 miles of 4-in. gathering and connecting pipe lines to take crude oil from the Bebee field in Pontotoc County, Oklahoma, for its refinery at Allen, Oklahoma. Announcement of the line was made by F. L. Martin, vice-president in charge of refining. The line was constructed of reclaimed pipe. Construction of the line was handled by Pipe Line Service Company.

Bids have been received by the Sinclair Refining Company, Pipe Line Division, for construction of 22 miles of 14-in. pipe line to loop the company's main trunk line between the Manuel station, near Drumwright, Oklahoma, and the Indian station near Prue, Oklahoma, to increase the movement of crude oil. New pipe already on the ground will be used in the line.

Midwestern Engineering and Construction Company is progressing in the laying of pipe for river crossings of the Stanolind Pipe Line Company system across the Canadian and Red rivers. More than 6000 ft. of 8-in. line has been laid across the Canadian River and tied-into the system. A crossing of the Red River near Burkburnett, Texas, will require laying 7000 ft. of 8-in. expected to be completed after a week's work.

The construction of loops for the Stanolind company between Washington, Kansas, and Freeman, Missouri, has been completed to effect delivery of crude oil from Wyoming into the Sinclair Refining Company line at Stilwell, Kansas.

An application has been received from the Independent Natural Gas Company, a wholly-owned subsidiary of Phillips Petroleum Company, by the Federal Power Commission, Washington, D. C., for permission to build an 877-mile, 22-in. natural gas pipe line from Ray, Texas, to Milwaukee, Wisconsin. Purpose of the line is to permit the company to sell gas at wholesale rates to 10 public utilities operating in southern and eastern Wisconsin for resale to the public.

P 729.7

THE Petroleum Engineer

MARCH, 1942

Economics of the Alkylation Process in the Production of High-Octane Gasoline

☆ **Availability of charging stocks is of primary importance and adequate sources of blending stocks within the refinery are vital to low production cost.**

by R. G. Lovell

Development Engineer, Hancock Oil Company of California

ANY discussion of the alkylation process that is purely technical in scope usually misses the main objective: Will the process return a profit in a specific set of conditions, and what are the prerequisites required to make it a profitable operation?

There is not a scarcity of information regarding the fundamentals of the process. Chemists have been familiar for some time with the reactions involved, but it remained for the emergency of national defense to translate the theory into a profitable industrial operation despite the large capital investment required per barrel of finished product.

It is the objective of the writer in this article, therefore, to place more emphasis on the refinery economics of the process than upon the details of design, construction, and operation. Full consideration also will be given to the market possibilities of the product after the period of the emergency has passed. The writer does not feel that training as an economist has equal value in this discussion as does the experience of refinery men and the distinctly realistic viewpoint that is a result of such experience.

Decisions to build the earlier alkylation plants were based in a large degree upon the very attractive price offered for a 100-octane aviation gasoline with specifications of vapor pressure and distillation range that practically precluded use of conventional manufacturing methods.

Charge Stocks

Discussion of the economic feasibility of an alkylation plant must, necessarily, begin with a survey of available

R. G. LOVELL

received his academic training in New York and served several of the larger mining and milling companies of New Mexico, Arizona, and the Republic of Mexico as power engineer and master mechanic from 1908 to 1917, then saw military service in the engineering corps until 1919—Returning from the war he became affiliated with the oil refining industry, first with Standard Oil Company of California as refinery construction engineer and later with a foreign company—Later he was made assistant to the chief engineer of Pan American Petroleum and Transport Company for the construction of their California processing properties—He has been with The Hancock Oil Company of California since that time.

materials for charging stocks. Experience has shown that these are currently limited to two hydrocarbon gases of the *iso* type, one of which must be predominantly olefinic, and these must be practically equal in quantity and both relatively free from contamination with their associated normal compounds. It is to be noted that, beginning with charge stocks, all similarity with conventional refining methods ceases. The first point of divergence is pertinent to the economic study. In conventional refining, either straight-run or cracking, the charge stocks consist of large groups of hydrocarbons that can vary rather widely in specific gravity and distillation range without vitally affecting the process. In alkylation this is definitely not the case. One of the two stocks used is a single hydrocarbon of the paraffinic series, *iso*butane, and the other is a very small group of the unsaturates, butylenes. They are not large groups of hydrocarbons containing, perhaps, several hundred units with a wide range of boiling points. These two stocks are brought together under stated and carefully controlled rate and temperature conditions in the presence of a catalyst, usually a concentrated sulphuric acid. Any degradation of either of the charged materials, or of the catalyst, is immediately reflected in lower volume of output and quality of the product. Obviously, then, our study must begin with a determination of availability of the one charge stock, the amount of which is a function of one's own conventional refining plant.

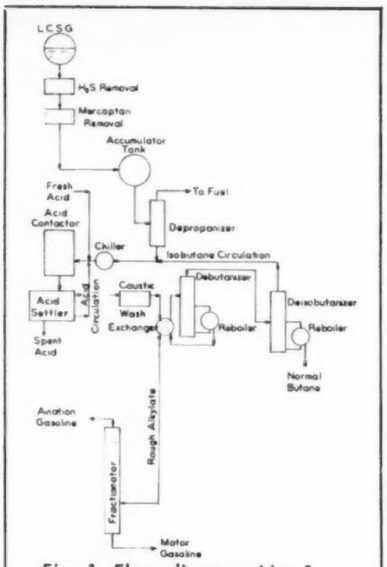


Fig. 1. Flow diagram No. 1—Alkylation unit

TABLE I
Mols

	From condensate receivers	From stabilization of pressure distillate	Available for alkylation plant feed and for blending
Inert (H_2S CO_2 H_2 N_2)	299	....	....
Methane—C_1	1306	15	....
Ethene—C_2	172	19	....
Ethane—C_2	654	82	....
Propene—C_3	283	108	....
Propane—C_3	445	174	....
*Iso*butane C_4 i	58	57	115
Iso and 1-butenes—C_4 i—C_4 1	119	134	253
Normal butane C_4	140	180	320
2-butenes C_4 2	85	99	184
Pentanes plus—C_5 plus	199	3540	....
mols per day	3760	4438	872

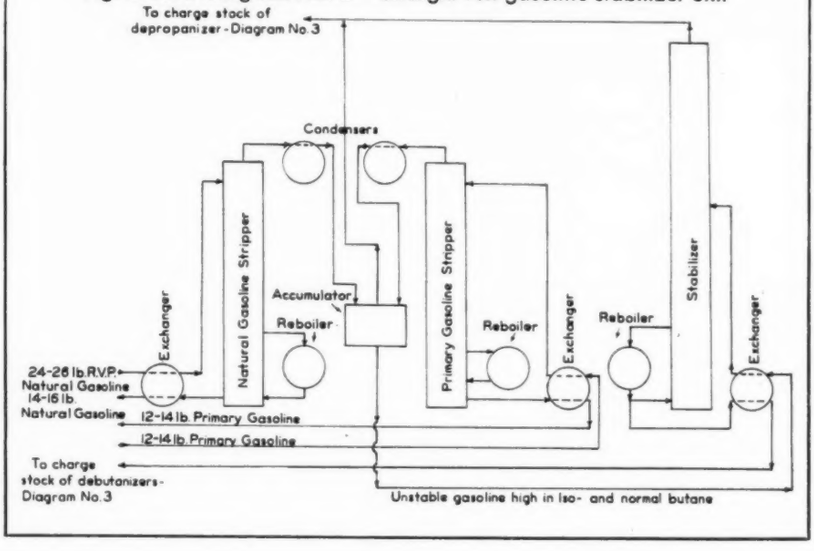
This stock is the unsaturated half of the pair and consists of the butylenes. It is found in the overhead product of the cracked gasoline stabilizer. The volume available is generally dependent upon the throughput of the cracking plant, but is influenced materially by the depth of cracking practiced and to the vapor pressure point of the stabilization. For example, if the pressure distillate is stabilized to a Reid vapor pressure of 4.5 lb. instead of 10 lb., the amount of butylene thus made available is greater. The cracked gasoline can then be returned to a normal vapor pressure for blending into motor gasoline by use of normal butane. This exchange offers some very interesting and valuable possibilities, but these will be discussed later. As the volume and content of the cracked vapor is partially a function of the depth of cracking practiced, the unit of cracking plant charge stock will not be used. Instead, hypothetical amounts and analyses of cracked gas and pressure distillate will be used as our guide.

Typical Conditions

Assume to be available directly from condensate receivers, 1,500,000 cu. ft. per day of cracked gas at standard temperature and pressure, and 1800 bbl. per day of raw pressure distillate to be stabilized to 4.5 Reid vapor pressure. Table 1 shows the mols of the various components that will be available.

Present calculations are only for the purpose of determining the number of mols per day of butylenes available from a cracking operation that it is necessary to equal with mols of *iso*butane from all sources. This number of mols per day of butylenes will be the addition of 253 and 184, or 437. Perhaps the best way to determine how much alkylate per day can be produced from the 437 mols of butylenes per day will be to set-up a desired out-turn capacity. The butylene volumes herein given are relatively small, as is the usual cracking plant capacities, and it will be in order to use a low tentative capacity figure for the hypothetical alkylation plant. The smallest size plant currently considered as economically feasible is 100 bbl. per day of finished alkylate. The end product is generally about 65 A.P.I. and, therefore, weighs 5.97 lb. per gal. The pounds of alkylate will be $5.97 \times 100 \times 42 = 25{,}074$. As this will be composed of about half butylenes we have 12,500 lb. of bu-

Fig. 2. Flow diagram No. 2—Straight-run gasoline stabilizer unit



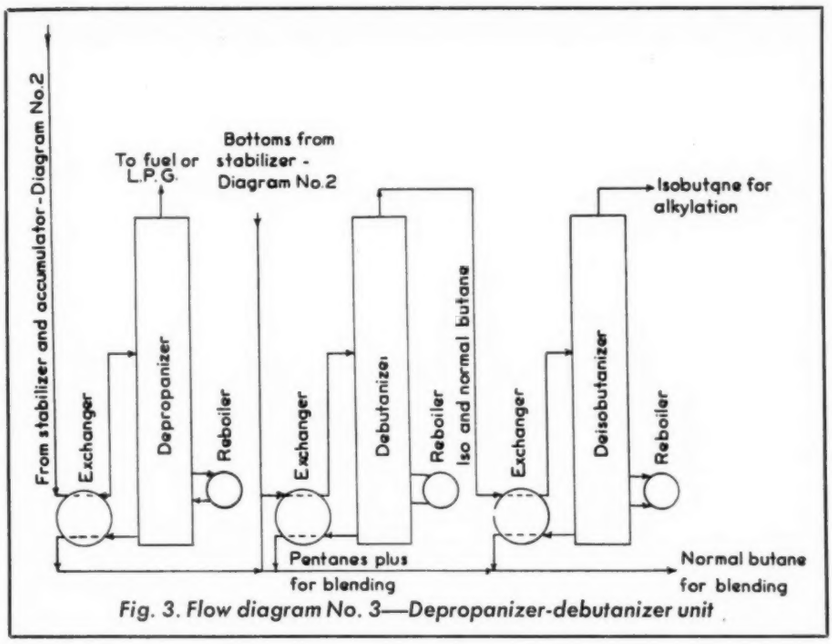


Fig. 3. Flow diagram No. 3—Depropanizer-debutanizer unit

tylenes required. Dividing by 56, the molecular weight of butylene, there are approximately 225 mols per day theoretically required.

The first and natural reaction to this figure is that 100 bbl. per day of plant capacity can immediately be revised upward. This is not, however, a sound conclusion, for it must be borne in mind that in arriving at the 437 mols per day of butylenes, the objective was to strip the pressure distillate to a very low vapor pressure, 4.5 lb. per sq. in. Some difficulties, such as greatly increased cost of apparatus, might arise in accomplishing such a degree of stripping and in that case it might be better to leave a portion of the butylene 2 in the pressure distillate. In any event, it is always advisable to have an excess of butylenes available as a safety factor in designing the plant.

Sources of *Isobutane*

To enumerate the potential sources whence might be obtained the *iso*butane required to balance the butylenes recovered from the cracking operation is not a satisfactory answer to the problem, particularly when the objective of the discussion is primarily economic. A broad view of the problem will show each detail in its relationship to the other elements, and if inspected carefully will develop some very interesting and potentially profitable ideas.

It is presumed that a refinery of even moderate capacity would be equipped with a system for recovery of vapors from gasoline and crude oil tanks. As stabilization of pressure distillate would be carried on in a closed circuit we can expect to find only paraffinic vapors in the product of the vapor recovery plant. From a combination unit running about 10,000 bbl. of crude oil per day, we have reason to expect an *iso*butane recovery of about 30 mols per day from the tank vapors.

The primary cut from the straight-run can be estimated as 7½ percent of the total crude oil or 750 bbl. per day. Its vapor pressure would probably be 14-16 lb. per sq. in. abs. To use this stock in itself as a base for premium fuel would require stabilization. Preferably, this is accomplished in separate units to avoid mixing with cracked stock. The mol percentage of the *iso*butane in the raw primary can be taken as about 1.6 and the mols per gal. as 0.055. From the 750 bbl. per day, or 31,500 gal. per day, we can expect to recover $31{,}500 \times 0.055 \times 0.016 = 28$ mols per day.

Inspection of Table 1 shows that 115 mols per day of *iso*butane are available from the pressure distillate accumulators and stabilization of the distillate. We now have, therefore, a total of 173 mols per day of *iso*butane. The alkylation of the 437 mols of butylenes per day on hand will require at least 264 additional mols per day of *iso*butane.

Potential Blending *Isobutane*

There is still another potential source of *iso*butane, a study of which will develop the interesting factors previously referred to. Some years ago when liquid petroleum gas was first introduced, the market for it was very limited and the percentage of butane—normal and *iso* together—in wet casinghead gas was more than ample to supply the demand. Motor gasoline specifications were rather lax with respect to vapor pressure, and natural gasoline with as high a vapor pressure as 26 was often used as a light blending stock. In fact, 21-lb. Reid vapor pressure was more or less standard. As the demand for bottled gas increased the natural gasoline manufacturers became more interested in cutting deeper into their charging stock for the production of more liquid petroleum gases and consequently offered a 15-16 Reid vapor pressure blending stock at a reasonable price. This fitted in well with the motorist's demand for relief from vapor lock troubles and also permitted the refiner to take greater advantage of low sulphur content as a diluent.

Another Trend

A primary cut of straight-run gasoline is preferred as a base stock for Ethyl gasoline because of its better lead susceptibility—due to low sulphur—and low gum-forming tendencies. The average percentage of this stock in a barrel of crude oil is seldom greater than 10, and although this amount was adequate for a long time, the increasing demand for premium motor gasoline and for domestic grade aviation gasoline has about balanced the available supply of narrow distillation range, low endpoint, straight-run stock to be distilled from crude oil. In fact, this situation is acute at present and more sources must be developed or sacrifices made in quality of premium motor gasoline.

Increasing *Isobutane* Stock

The process now to be developed is not offered as a substitute for isomerization, either by catalytic or thermal

TABLE 2

Typical composition of a primary and a 27 Reid vapor pressure natural gasoline

Fraction	Unstabilized primary 15-16 RVP		Natural gasoline stabilized to 27 RVP
	mol %	% by liquid volume	% by liquid volume
Methane	....	....	....
Ethane	0.3	0.20	....
Propane	3.1	1.94	....
Isobutane	2.0	1.54	7.40
N-butane	7.7	5.59	27.71
Pentanes plus	86.9	90.73	64.89
	100	100	100

conversion of normal butane to butylenes, or by refractionation of the pentanes for isolation and recovery of *iso*-pentane of high octane value. Each of these processes has certain definite advantages and applications to certain conditions, which will be discussed later. For the present the search is for a definite amount of *iso*butane by the simplest method.

It is reasonable to assume that 20 percent of the crude oil throughput could be converted into straight-run gasoline and blending naphtha. Using the figure of 10,000 bbl. per day as a base, we have 10,000 × 0.20, or 2000 bbl. per day of gasoline blending stock, which may require up to 25 percent of its own volume in light blending material (natural gasoline) in order to meet specifications for the lower end of the distillation curve and for maximum sulphur. The exact amount to be used will depend upon the Reid vapor pressure of both the light and heavy stocks, their 10-percent points, and the Reid vapor pressure and sulphur specifications of the completed blend. For present purposes it can be assumed that 20,000 gal. per day of natural gasoline will be required for blending. Further, 10,000 gal. per day of additional straight-run base for premium motor fuel is needed. This latter stock is to be limited in Reid vapor pressure to 12 lb. The percentages, amounts, and specifications are not represented as typical of any individual case but will serve the present purpose.

Stabilization

Fig. 2 shows the manner of accomplishing the first step in stabilization. Separation of the normal and *iso*butane is shown in a separate diagram (Fig. 3) to avoid confusing the reader who might have reason to use the idea of stabilization for recovery of the bottoms product and the overhead for liquid petroleum gases, or for sale to other plants requiring *iso*butane for alkylation. The normal butane remaining is suitable for blending into motor gasoline, for conversion into *iso* form, or for additional butylene recovery. It should be noted that each of the diagrams submitted is entirely schematic and that they may be combined into a single unit, or each may be used separately as conditions indicate. No attempt has been made to show sizes of apparatus, temperatures and pressures, or any of the control equipment. There is nothing experimental about them, the tolerances are well defined and the necessity for these tolerances should be understood Failure of primary apparatus and its auxiliary equipment to function satisfactorily over a wide range of duty more often than not can be traced to a lack of coördination between executive and engineer. The engineer of experience, in his endeavor to provide for excess capacity, which is almost always demanded, will specify equipment considerably greater in capacity than the specified duty.

The writer is attempting in this article to make it possible for the executive to become so familiar with the simple fundamentals controlling the design that he can define more clearly for his engineer the maximum requirements of the apparatus. The engineer can then design the large vessels to fit this maximum and hold other parts of the equipment to current needs with everyone cognizant of these limitations. Much capital can often be saved by such procedure without later recriminations.

It will be noted that the *iso*butane percentage of the primary gasoline shown in Table 2 is not the same as that used in a calculation previously made. This is not unusual as often these will vary considerably. Both values are taken from actual analyses and prudence indicates use of the lower value.

This article is intended to be more in the nature of an economic survey than a technical study and will not cover the relationship percentage by liquid volume and molecular percentage. Engineers and chemists understand it as a part of their fundamental training, and the executive who does not understand it will do better to seek clarification from his own engineer than to endeavor to work the point out by study.

To determine what number of mols per day of *iso*butane we can count on from 1,000,000 gal. per month, or 33,333 gal. per day, of 26-27 Reid vapor pressure natural gasoline, the method is as follows: the percentage by liquid volume of the *iso*butane fraction is shown in Table 2 as 7.4. The liquid volume of *iso*butane per day, then, is 7.4 percent of 33,333 gal., which is 2467, each gal. of which weighs 4.7 lb. The total weight of the fraction per day is, therefore, 2467 × 4.7 = 11,595, which, divided by the molecular weight of *iso*butane, 58, gives us 200 mols per day from the natural gasoline. This figure, added to the amounts already found in the primary and the pressure distillate, equals a total of 401 mols per day, an estimated balance for the butylenes.

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P 031.132

U. S. Bureau of Mines Research on Operating Phases of the Petroleum Industry

RESEARCH by the Petroleum and Natural Gas Division of the U. S. Bureau of Mines regarding various operating phases of the petroleum industry is proving of far-reaching importance to the Nation's war program, Dr. R. R. Sayers, Director of the Bureau, said early this month in announcing publication of a resumé of the division's activities during the fiscal years 1940 and 1941.

Long before the accelerated war-production program began, the division had launched its present studies of problems relating to petroleum and natural gas production with a view toward conservation of resources and more efficient utilization of petroleum.

The division's 7-point program during the biennium (July 1, 1939, to June 30, 1941) covered the following: (1) oil and gas development and production research; (2) petroleum chemistry and refining research; (3) pipeline transportation research; (4) special chemical and engineering problems; (5) helium operations; (6) work for other government departments; (7) visual education.

Prominent among the activities of the division are surveys of crude oils suitable for the manufacture of special aviation gasoline and the adaptability of refineries to produce this and other vital products, Dr. Sayers commented in submitting the report to Secretary of the Interior Harold L. Ickes.

Also of vast importance to the wartime production cycle were expansions of the Bureau-operated helium plant and gas field for the purpose of increasing the output of this non-inflammable gas for military, scientific and medical uses. The Bureau's helium plant at Amarillo, Texas, produced 16,250,000 cu. ft. of helium during the fiscal year 1941, or approximately 72 percent more than in the 1940 fiscal year.

Copies of the report may be obtained by writing to the Bureau of Mines, Department of the Interior, Washington, D. C., for Report of Investigations 3616, "Biennial Report of the Petroleum and Natural Gas Division, Fiscal Years 1940 and 1941," by R. A. Cattell, G. B. Shea and others.

☆☆☆

P 420.116
P 429.2

Directional Drilling Deflects Hole into Productive Zone

Exclusive

☆ Modern drilling practice deflects hole 326.66 ft. with approximately one-third added drilling time and cost

by C. C. Pryor, Assistant Editor

FAILURE to find production on a lease in an East Texas field recently led one operator to resort to directional drilling to find a productive zone. Although deflection of the hole from an unproductive to a productive portion of a lease is common practice in these days of modern scientific drilling, the cost of an abandoned hole, which may include casing lost in the hole, besides the cost of drilling machinery and materials, and scarcity of labor, is entirely prohibitive in the present national emergency.

As a result of deflecting the direction of the well there was no lost casing, drilling time, or machinery. There was an increase in drilling time of approximately 14 days plus the cost of directional drilling service, but final completion of the well as a producer at a cost of approximately one-third more than a vertically-drilled well was regarded as ample compensation.

Referring to Fig. 1, it may be seen that from the point of plugging-back to deflect the hole, it required three days less to drill the vertical hole than to drill the deflected hole. The extra time to drill the deflected hole was the direct result of fishing jobs, cleaning and conditioning the hole, single-shot surveys, plugging back, and setting whipstock.

Fig. 1 also shows the time necessary to drill from the surface to the plug-back point as 14 days. Obviously, this was not all drilling time, as records of the well showed that the hole was spudded-in, drilled to 970 ft. with a 12¼-in. fishtail bit, the bit changed to a rock bit at this depth and drilling was continued to 1850 ft., at which depth 8⅝-in. casing was run and cemented, after which there was a waiting period of 72 hours to allow the cement to set.

After testing the surface casing and drilling the plug, the records show that four 7⅞-in. fishtail bits and two rock bits were employed to drill the vertical well to 4660 ft. through shale and shell.

At 4660 ft. a deviation test showed the hole to be vertical.

Two rock bits were then used to drill the hole to 5235 ft. From 5235-5255 ft., 20 ft. of hard sand was cored, indicating the first gas sand. A second core was taken from 5255-5270 ft. and disclosed a second gas sand. The third core from 5270-5274 ft. was hard sand with no gas. Core No. 4 was sandy shale from 5274-5279. Core No. 5 recovered 2½ ft.—one ft. of shale and 1½ ft. of hard sand. Core No. 6 was taken from 5284-5288 ft. Two and one-half ft. of the core was shale and the remainder sand. Hard shale was recovered in a seventh core from 5288-5290 and from 5290-5294 ft., sandy shale. From 5294-5340 ft. core recovery was complete, the core showing hard sandy shale with lime streaks.

An electrical log of the well showed no formations that could be considered productive.

Following the operator's decision to deflect the hole in the hope of finding a productive zone in another portion of the lease, open-end drill pipe was run in the hole and a cement plug placed at 1983 ft. Two days were then spent waiting for the cement to set.

After running a fishtail bit to clean the hole, a single-shot instrument was

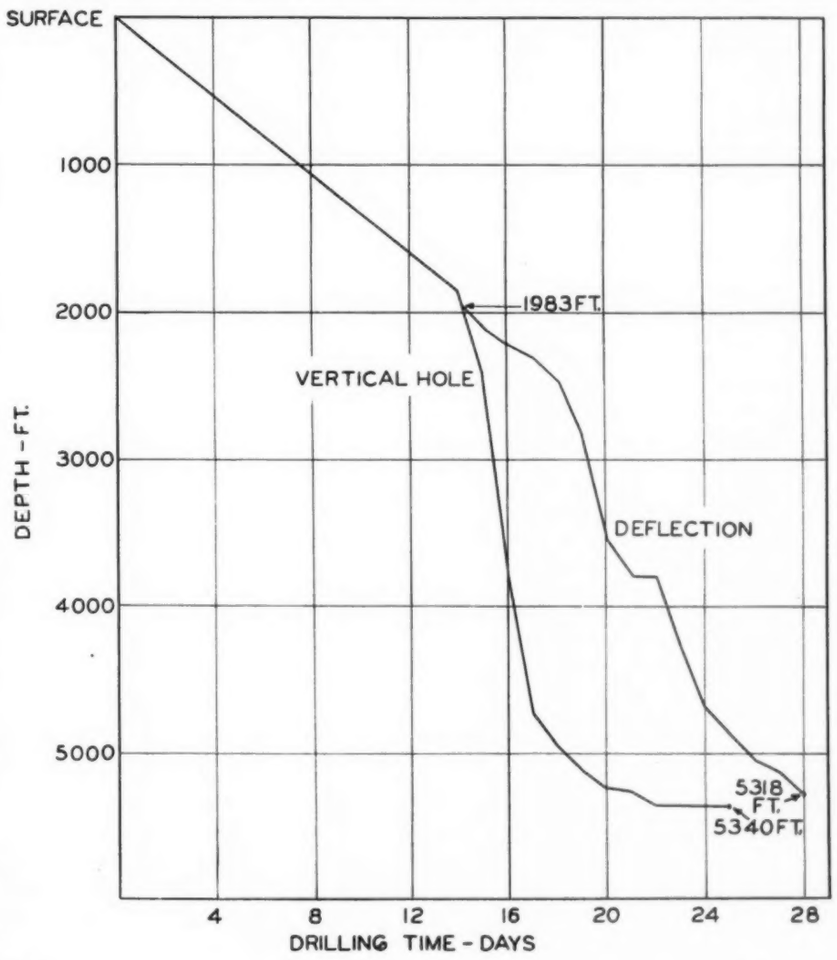

Fig. 1. Graph showing depth of vertical and deflection holes and drilling time. Hole was plugged-back to 1983 ft.

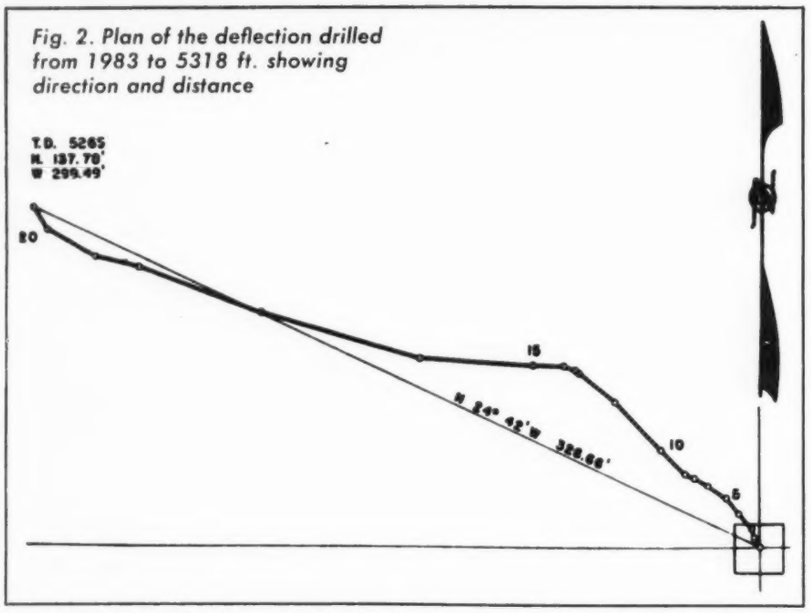

Fig. 2. Plan of the deflection drilled from 1983 to 5318 ft. showing direction and distance

run to survey the hole immediately below the casing. A deviation of one degree was recorded.

A removable whipstock with a 3-degree angle on the face was employed in deflecting the hole. The first attempt to run the whipstock failed. A bit was then run with a drill collar to circulate and the whipstock rerun and then set by using the bottom-hole orientation method. Following the usual practice of drilling an 18 to 22 ft. section before removing the whipstock, a 5¾-in. bit was used to drill a 20-ft. rat-hole off the face of the whipstock at a 5 deg. angle. The whipstock was then removed and the hole reamed with a pilot reamer bit to 2005 ft. A drag bit was then used to drill to 2158 ft. The hole was surveyed for deviation and direction at this point and showed an angle of drift of 4 deg. 15 min. (see Table I).

A second whipstock was set at 2158 ft. and the hole deflected and drilled 18 ft. with a 5⅜-in. bit. After drilling and reaming to 2312 ft., a single-shot instrument was run to determine the deviation and direction.

Three single-shot surveys were made at this point in the drilling at depths of 1850 ft., 1000 ft., and 500 ft. A three-way drag bit reamer and a 15-ft. 5-in. long drill collar was then run into the hole with the reamer 255 ft. off bottom. The hole was then drilled 90 ft. with 8 points of weight and a rotary speed of 80 r.p.m. The single-shot instrument was again run at 2312 ft. After drilling to 2400 ft., a 7⅞-in. drag bit was run and the hole reamed, carrying 8 points on weight indicator and a rotary speed of 85 r.p.m. Fish-tail bits were then used to drill the hole to 3685 ft., the single-shot instrument being run when bits were changed at 2410, 2637, 2845, 3080, and 3565 ft., respectively.

In drilling from 3685 to 3778 ft. a 7⅞-in rock bit was used at 8 points on weight indicator and rotary speed of 80 r.p.m. While running the single-shot instrument the line broke, so a rope spear was run and 300 ft. of line removed. An inside spear was run, but the operators were unable to lower it far enough into the hole to reach the broken line. The rope spear was again run, but only 10 ft. of line was recovered. The next trip recovered 20 ft. and the last brought up the line and single-shot instrument. One day was lost on this fishing job.

From 3778 to 3798 ft. hard shale and line were encountered. A 7⅞-in. drag bit was run and then the single-shot instrument, but it would not go below 2160 ft., so it was necessary to run in a bit with a reamer 10 stands up and ream to 2895 ft. A drag bit was run and it took three and one-half hours to work to bottom. The single-shot instrument failed to go below 3500 ft. and another drag bit was run in and washed down. The single-shot was run at 3888 ft.

During the drilling from 3888 to 4420 ft., a fishtail bit was used with a reamer in the drill string above the bit. After running a single-shot at 4420 ft., it stuck at 4050 ft. In trying to remove the instrument the sand line broke and necessitated the use of the rope spear again. On the first trip with the spear, 4100 ft. of line was recovered and the second trip brought the remaining line and single-shot.

The Austin Chalk, found at 4600 to 4915 ft. in the vertical hole, was found at 4685 to 4955 ft. in the deflected hole.

Coring from 5280 to 5300 ft. recovered shale, sandy shale, and sand. Core No. 2, from 5300 to 5308 ft., with full recovery, indicated a gas sand. From 5308 to 5312 ft. the top three ft. of the core indicated a gas sand and the lower remaining foot a hard oil sand. This was core No. 3. Number 4 was an oil sand core taken from 5312 to 5317 ft. Core No. 5 also revealed oil sand from 5317 to 5318 ft.

A string of 5½-in. casing was set to 5318 ft., six in. off bottom. After cementing, the casing was tested and the cement plug drilled-out from 5245 to 5318½ ft. with a 4¾-in. bit. The string of 2-in. tubing was then re-run with a perforated nipple on bottom. The Christmas tree was then connected, tubing swung in the hangers, and the well washed-in with water for a successful completion.

In Fig. 2 may be seen the course of the well from the plug-back depth of 1983 ft. The final bottom of the hole was N 24° 42 ft. W, 326.66 ft. from the derrick. —☆☆☆—

TABLE I
Survey record

Survey No.	Measured depth	Angle of of drift	True vertical depth	Deviation, feet	Direction of drift
1	1865 00	vertical			
2	1983.00	1° 00′	.....	2.06	S 13° W
3	2 05.00	5° 00′	.....	1.92	West
4	2066.00	5° 00′	.....	5.32	N 80° W
5	2158.00	4° 15′	2157.42	6.82	N 83° W
6	2176.00	7° 30′	.....	2.35	N 80° W
7	2222.00	10° 15′	.....	8.19	N 71° W
8	2312.00	10° 45′	.....	16.79	N 71° W
9	2410.00	11° 00′	.....	18.70	N 70° W
10	2637.00	11° 30′	2627.60	45.26	N 68° W
11	2845.00	12° 00′	.....	43.24	N 66° W
12	3080.00	11° 00′	.....	44.84	N 68° W
13	3565.00	9° 45′	.....	82.11	N 54° W
14	3888.00	7° 45′	.....	43.57	N 59° W
15	4150.00	5° 30′	4120.59	25.10	N 59° W
16	4600.00	4° 45′	.....	37.26	N 57° W
17	5050.00	3° 15′	.....	25.51	N 57° W
18	5280.00	3° 15′	5247.97	13.04	N 57° W

The Question of Petroleum Reserves

☆A pertinent discussion of the sufficiency of United States petroleum supplies during the war period and for the future.

by Prentiss T. Moore

POTENTIAL war demand on United States petroleum reserves is bringing to the fore again an old question, one that basic conditions in oil supply and demand were beginning to revive a little even before this nation was drawn into heavy national defense preparations made necessary by the Second World War.

The question was a popular subject of debate in the second decade of this century, particularly during and for a while after the First World War. Changed conditions made it unfashionable in 1921. It was forgotten by the rank-and-file after 1927; and since then, although apparently kept somewhat in mind in some higher circles, has been tabled along with other general speculation on the future of the American oil business and that vast domestic economy directly or indirectly dependent on petroleum for existence.

Two quotations, one from a very recent report and the other a famous "utterance" of more than 20 years ago, indicate the general nature of the question:

1. "The declining rate of additions to these reserves is rapidly approaching the amount currently being withdrawn as production; and unless the downward trend is reversed the total of new discoveries can be expected to fall below the amount of crude required."—*From report of the Committee of Nine to Secretary Harold L. Ickes, published February 5, 1942.*

2. "The path which lies just ahead of us may traverse the foothills of temporary conditions, but just beyond lies the mountain which in the end must be scaled, and that mountain is the petroleum consumption of the future."—*From an address before the American Petroleum Institute in December, 1921, by Walter C. Teagle, then president, now chairman of the board, the Standard Oil Company (New Jersey).*

The question—Is the United States at last approaching that time when its oil drills might not be able to find petroleum as rapidly as it is eaten up by a consumption still strongly increasing?

Involved are several special questions.

Pertinent to war—Are United States oil reserves sufficient for a *prolonged* war without continued heavy drilling, continued heavy discovery, continued careful use of natural lifting forces?

Pertinent to the consumer public and the oil business—Is the era of *cheap oil*, which began about 12 years ago, perforce ending?

PRENTISS T. MOORE

wrote an oil news column for the *Muskogee Phoenix* in 1913—In 1915, went to Tulsa, Oklahoma, as staff correspondent of the *Fuel Oil Journal* of Houston, Texas—Continued in charge of Mid-Continent section of that journal after it moved to New York in 1917 as the *Oil Trade Journal*—In 1919, was in Dallas for a year under contract with the Chamber of Commerce "to put Dallas in the oil news datelines"—From 1919 onward, was an occasional contributor to New York dailies, especially the *Wall Street Journal*, of articles on general aspects of the oil business—From 1920 until into the middle 30's also acted as private correspondent for eastern banking and stock-and-bond houses, as a specialist in the matter of the United States crude oil supply—For the last 14 months has been gathering data for a history of the petroleum industry since the Dissolution Decree.

Pertinent to national economy—A quotation from an address by a great oil leader nearly a quarter of a century ago suggests a question of current applicableness:

"Needs of our own government and our allies for petroleum in the actual conduct of warfare are first to be considered. . . . But the demand for petroleum and petroleum products is not alone in the actual conduct of warfare.

"Here are the broad outlines of our problems. What should be borne in mind is that petroleum products, while vitally essential to the uses of war, also have other uses intimately related to our daily lives. . . . It can be said that we can get along without the automobile. The same can be said of the telephone. But we know that without those instruments of civilization, the horizon of our life would be greatly reduced, and the efficiency of our civilization would be curtailed. The automobile has come not to be a mere article of luxury. It has come to be a necessity, to the merchant and the manufacturer in the cities, to the farmer on the plains, and the miner in the mountains. The automobile industry has become one of our great national assets, contributing enormously to the progress of civilization itself. . . .

"So that while the situation is not one for immediate alarm, it is one for taking intelligent measures toward adequate production of what we need."—*From an address before the United States Chamber of Commerce at Atlantic City in September, 1917, by Alfred Cotton Bedford, chairman of the War Service Committee on Petroleum, then on vacation from his position as president of the Standard Oil Company (New Jersey).*

In brief, the whole question relates to the status and sufficiency of the United States petroleum supply at this time, for the next few years, and for the indefinite future.

What Has Been Done to Build Up Domestic Reserves

Since the First World War—when the burden of supplying oil fell on the United States as heavily as it does now and when war boards at Washington were seriously concerned at shortage of crude at wellheads and no available reserves except scant and rapidly shrinking aboveground stocks—the United States petroleum industry has worked continually and systematically, with steadily improving science in geology and oil-well engineering, to build up and maintain in this country available underground reserves of oil in excess of current need.

This program has been persistently adhered to up to this time, apparently without regard for the fact that superabundance of oil necessarily forced a much less profitable business.

The search for more reserves has continued with such facilities for exploratory operations, such scientific powers of discovery, and such risk of capital as wildcatters of the First World War period never dreamed of.

In nothing has the oil industry made greater advance in the last quarter of a century than in its scientific means of seeking new oil fields. It has given birth to a new science—geophysics. It has called into active use, as in study of strata, sciences such as palaeontology and chemistry. The early oil prospectors, even well up into this century, sought out plain visual evidence of petroleum. Surface oil seepages led to the first subterranean discoveries in the Appalachian Regions, in California, in the Rocky Mountain district, in the Mid-Continent, etc. Such surface signs and rather random hit-or-miss guesses were the main reliance in the search for oil fields even

until the First World War. Geology had come into play, but, in 1914, oil geology was regarded as academic nonsense by many oil men. And geologists, for a long period, had to rely upon visual surface evidence of stratigraphic irregularities or such evidence as they could adduce from well-logs. Now the oil geologists utilize not only a vast and continually growing accumulation of geological knowledge of United States strata, they also utilize, by means of extraordinary instruments, the force of gravity, the earth's magnetic attractions, shock-waves that they themselves create; measuring the resistance of subterranean strata in such manner as to find places favorable for oil. Some have even used airplane reconnaissance of terrain or chemical surveys of top soil, by the one method finding evidence of "structure," by the other, evidence of petroleum beneath.

At the time of the First World War, oil-prospecting or wildcatting was largely a matter of individual efforts, usually of individuals of small means; now all large oil companies and many lesser ones have highly important exploratory departments. So common are the seismograph crews—who hunt with shock waves—that their activities are often listed as a phase of a district's oil development operations. A big percentage of the addition to U. S. oil reserves in the last 10 or 12 years has been due to these shock-wave geophysicists, particularly many of the deep discoveries.

The efficiency of this widespread discovery work is greater because of its coöperative spirit in freely exchanging geological information. Once development is started in a new area, all that is learned there soon becomes common knowledge. The bibliography of United States geology, surface and subsurface, is enormous, free to all.

The hunt has been both wide and deep.

Reserves have been increased as much by deeper drilling as by widening the search geographically. In 1915, Cushing's 2600-ft. wells were record-breakers for a worthwhile oil pool. In 1918, Ranger's 3600-ft. wells were the extreme. Santa Fe Spring's 5400-ft. wells in 1919 can be found in old reports with the note—"*First deep wells.*" But today, 10,000-ft. wells are rather common. By 1938, an exploratory drill ground down to 15,004 ft. In recent years, many of the richest discoveries have been unusually deep.

Geographically, the search has steadily widened until the oil possibilities of all of the 48 states have come under study, with holes soon begun wherever signs seemed favorable for oil.

The result has been huge.

For instance, from 1935 through 1941 new petroleum reserves discovered and more or less developed in the United States aggregated 15,500,000,000 bbl. of recoverable oil.

That in the same time 8,500,000,000 bbl. were taken out of reserves for consumption is another matter—the other phase of the general question.

Discovery Beginning to Fall Behind

After 1927—when the oil drills finally began to outrun an acceleratively increasing consumption that had begun early in the century, due to the automobile, etc.—available U. S. underground reserves increased for about ten years at a steadily climbing rate. The drills were not only able to keep up with the strongly rising demand, but also built-up large available reserves of the raw material of the petroleum industry. Then, about 1938, the arc of the climbing chart-curve of reserves began to break. Reserves have continued to increase, but not at the same rate as before.

Last year the curve threated to flatten out into a horizontal line. First estimate out on 1941 increase in reserves shows only a 1 percent gain.

Referring again to the report of the Committee of Nine, made public on February 5, 1942:

"If only new fields are considered, a downward trend in the rate of discovery began as far back as 1937. Since about 1938, the amount of oil found through new field discoveries had been less than the amount of crude extracted from the ground, even though the amount of the exploratory work, as measured by the number of dry holes drilled, has increased through the entire period."

As the Committee of Nine indicated, there has been no slackening of the hunt for more reserves in the last three or four years. On the contrary, the search with the exploratory drills has continued even a little more vigorously.

For example, approximately 7000 dry holes were drilled last year, or nearly a third as many dry holes as 1941 oil-well completions. A very great percentage of those dry holes were exploratory. So was a percentage of the completed oil wells.

Three times in the last five years the annual number of all holes drilled for oil or gas in the United States has touched or exceeded 30,000, a record-breaking drilling rate. Of those holes, 18 percent to 20 percent were listed as failures. That percentage represents fairly accurately the amount of work and capital that has gone into attempting to maintain underground oil reserves in due ratio to consumption.

With all the drills, the science, and the capital used in maintaining reserves failing for three years to discover new sources of supply as fast as older reserves are reduced by consumption, the question naturally arises whether the heyday of oil prospecting is over in the United States.

Only time can answer that question. There are still vast areas for search, and vaster depths.

As was pointed out in 1925 in a most exhaustive survey of United States petroleum resources by the A. P. I. Committee of Eleven:

"The major oil reserves of the United States lie in some one billion, one hundred million (1,100,000,000) acres of lands underlain by sedimentary rocks, in which geology indicates oil is possible."

That report continued with a point that was a good prophecy and is an index to still further possibilities:

"Improved methods of drilling below oil sands now producing will disclose in many areas deposits not hitherto available."

Those 1,100,000,000 acres and those deeper depths have been intensively explored since 1925. Many of their possibilities have been materialized into proved reserves. They still hold room for vast additional exploration. But as J. O. Lewis, then of the U. S. Bureau of Mines, said at Denver in 1920:

"Our petroleum resources are hardly to be compared with the buffalo and the carrier pigeon, which, as was said, were also once thought to be inexhaustible. We will still be finding oil in the United States one hundred years from now. But the question is—how much?"

A point frequently made in the 1925 report of the Committee of Eleven—"*when price justifies*"—is in line with the remedy for failing discovery work recently suggested to the Petroleum Coördinator by the current Committee of Nine. It is an evocation of the old rule, "*Pay the drill enough to keep it at work, and it will find the oil.*"

United States Oil Reserves of Today

United States underground petroleum reserves consist of hundreds of oil pools scattered, east and west from New York State to Los Angeles; north and south from Michigan and Montana to the southern tip of Texas. The reserves are proved and marked on the map by the nation's oil wells, now nearing 400,000 in number.

The proved reserves range from pools with as few as two or three oil wells up to the East Texas pool with 25,000 to 30,000 oil wells.

Some of the reserves are almost as old as the industry; some were proved as late as this week.

A few, of no large barrelage, are almost on top of the ground; a great percentage of the barrelage is thousands of feet down; some reserves are two miles deep.

About 75 percent of the reserves are in the Mid-Continent and Gulf Coast areas. More than half of the total reserves are in the State of Texas.

About 17 percent are in California, still unconnected by transcontinental

pipe lines with the rest of the United States.

The remainder are in the Rocky Mountain District, Michigan, Illinois, Indiana, Ohio, Kentucky, West Virginia, Pennsylvania, and New York State.

The wide scatterage of the reserves is matched by a similar wide scatterage of refineries and pipe-line systems —a fact that to a certain degree limits their general availability.

These reserves are now estimated to hold 19 or 20 billion bbl. of recoverable oil.

The Draft on U. S. Oil Reserves

Although building up of reserves has begun to falter, not from effort but from inability to find new fields fast enough, the draft on reserves is still increasing with an unbroken chart-curve inclined toward the vertical.

United States oil fields are being drawn on by consumption today for five times their yield at the outbreak of the First World War; for twice their yield in 1932; for 700,000 bbl. daily more than a year ago, and this year is certain to show further increase. Still ahead somewhere is the peak of that mountain Teagle was looking at in 1921.

The annual increase in draft on U. S. oil wells since 1914 is shown by the following table of annual yield:

Year	*Output (Round Numbers) Bbl.*
1914	266,000,000
1915	281,000,000
1916	301,000,000
1917	335,000,000
1918	356,000,000
1919	378,000,000
1920	443,000,000
1921	470,000,000
1922	558,000,000
1923	726,000,000
1924	714,000,000
1925	765,000,000
1926	771,000,000
1927	900,000,000
1928	903,000,000
1929	1,010,000,000
1930	900,000,000
1931	857,000,000
1932	788,000,000
1933	899,000,000
1934	904,000,000
1935	997,000,000
1936	1,100,000,000
1937	1,260,000,000
1938	1,200,000,000
1939	1,256,000,000
1940	1,335,000,000
1941	1,390,000,000

A composite of various tables—The level from 1927 to 1934 was due, first to storing some of the output aboveground, later to supplementing output from aboveground storage. As a result of proration practices in recent years, the trend has been to build-up underground stocks of crude and to hold aboveground stocks to minimum working needs.

Available Oil in U. S. Reserves

How much petroleum available for early use is in United States reserves no one knows. On that point, there are no estimates. Certainly the amount would be only a fraction of the estimated 19 or 20 billion bbl. of recoverable oil.

"Reserves," as the word is used, means "*underground inventories of crude petroleum known to be recoverable.*"

Estimates of reserves do not take into consideration either time or cost.

They consider only the question of oil recoverable by modern oilfield engineering practices.

Theoretically, the United States now has 12 or 14 years proved oil supply. Some commentators on reserves so state.

Such a conclusion is extremely erroneous.

There are several reasons why the theoretical supply, if not continually augmented, would fall far short in 12 or 14 years; in fact, in much sooner time.

First is the fact that the 19 or 20 billion bbl. in reserves are down in the earth; a great deal a mile or more deep; some as deep as two miles.

Second is the fact that only a fraction of the petroleum now estimated to be in underground reserves can be recovered in 12 or 14 years. All past history of the oil business proves that. With the benefit of all the scientific advancement in oil-well engineering, which also has made enormous progress since the First World War, much of the proved underground oil cannot be got to the top of the ground within a much longer time. Recovery is a gradual and extremely long-drawn-out process. Some of the oil now counted in recoverable reserves will still be in its subterranean beds 50 years from now or longer. No inconsiderable percentage of the estimated 19 or 20 billion bbl. is in fields 30 or 40 or 50 years old or older, where ancient wells are still slowly draining hundreds of old oil pools.

Third is the fact that consumption is still on the accelerative increase.

Should war be long or should the enemy successfully attack the Russian and Near East sources of petroleum, the factor of increasing consumption would cut still faster into United States reserves.

Should war exigency—such as need for haste in getting oil out — force waste of natural lifting forces or abandonment of engineering conservation, such as foregoing the full benefits of natural gas and water drive, the estimated reserves would fall off to the extent of the loss of ultimate recovery.

Then there is the matter of cost. Much of the known recoverable oil now in reserves must stay there until it can be sold for enough to pay for its extraction. Of the nearly 400,000 oil wells in the United States today, the great majority are already down to such a low level of per-barrel output that their operation is a matter of eating up principal rather than living on interest. Pennsylvania alone has more than 80,000 wells averaging hardly more than one-half barrel daily. Ohio has 30,000 or more wells that hardly average one-third of a barrel in daily output. In all the oil states except possibly Mississippi, recently come into production, are thousands or tens of thousands of "stripper" wells, representing altogether an appreciable percentage of the total estimated underground reserves. Operated now at an economic loss, so far as their owners are concerned, they cannot be equipped with the more costly processes of final recovery until "*price justifies.*" Indeed, the rate of abandonment of stripper wells in recent months is a cause for concern. On the other hand, many of the very deep fields discovered in the last seven or eight years may be extremely costly to operate by mechanical lift once their natural sources of energy are gone.

How much of this proved underground oil in the United States could be made available quickly is highly problematical.

There is a popular belief that the United States fields now have so much oil at wellheads in prorated areas that by mere turning of valves the current output of all fields could be doubled, or that by merely allowing more oil to come from prorated wells, the current rate of U. S. output could be maintained for two or three years.

For instance, it is said occasionally that East Texas alone, if opened up, could take care of United States needs for a year.

This view is strongly disputed by men of long experience and in close touch with all phases of modern production practice. They incline to believe there would be many bad surprises in the oil states if all prorated fields were given a few days open-flow test. They believe potentials to be greatly exaggerated in many pools. They also point out the physical impossibility of many prorated fields quickly or soon doing much more than they are doing, for lack of facilities to move a much larger output. They say that much greater flow for any considerable length of time would seriously cut down the ultimate recovery of many prorated or back-pressure fields, through injury to oil sands and pre-

mature exhaustion of natural lifting forces.

It is generally doubted by experts whether the East Texas field could sustain a wide-open natural flow for 30 days. In fact, the East Texas field is a good example of the overrated "potentials" of many reserves. Statistically, the great field might still hold enough petroleum to equal a year's need of the United States. But it might require 10 or 11 years longer, at the present rate of flow, to produce that year's need, and actually will require several decades to get to the top of the earth all its estimated "reserve." The question regarding East Texas field is not how much additional oil it could now produce, but how much longer it can produce at its present rate. It is pointed out that the big fields' 400,000 or 500,000 bbl. daily output for the last 11 years has already drained natural reservoir energy to such an extent that thousands of wells are pumping and that the field is now producing as much salt water daily as oil. (Of the salt water produced, it is estimated that about 16 percent is being forced back into the reservoir as a means of disposal and to aid in maintaining water-drive.) State authorities and property owners there are concerned over a recent sharper drop in underground pressure, which is already nearing a point that may threaten the flowing life of many wells now producing by natural flow. Unless the remaining natural energy is most carefully conserved, thousands more of East Texas wells might soon be unable to flow their oil and that at a time when scarcity of materials might prevent installation of pumping equipment.

It is agreed that the United States has available petroleum in abundance for every conceivable emergency of war or domestic economy—for awhile. And agreed that with continued heavy drilling, this abundance can be maintained for years yet.

The question concerning the decade ahead is different.

Bedford's remarks in 1917 on the importance of petroleum in national economy are so *apropos* to the present that they need no elaboration. The only difference is that when he was speaking in 1917, there were about 4,500,000 motor vehicles in the United States. Today there are about 34,000,000; also nearly 2,000,000 tractors, etc. If petroleum was important in interior economy of the United States in 1917, it is five times that important today. As the United States is the only great nation that enjoys the petroleum industry as a big and widespread domestic activity, so does the United States' high standard of industrial efficiency depend on petroleum to a much greater degree than in any other land.

To the demands of the vast national economy based on petroleum have been added the demands of war. And the added demand has come just at a time when all that the American oil business could do to maintain adequate reserves was beginning to fall short of average results.

Disregarding the additional drain of war, it is quite possible that within a very few years, in the early future rather than the indefinite future, the United States will again be confronted by a "chronic shortage" in the domestic supply of crude petroleum.

For the last three or four years, oil men have been watching the still-increasing consumption of oil and the slower increase in reserves, with the feeling that the time was nearing when the superabundance of the last 10 or 15 years might end. Science can find oil deep in the earth, but cannot put it there. In the last 12 or 15 months, this watchfulness has grown more tense, as the exploratory drills have continued to fall behind in results. In July, 1941, Frank Phillips, chairman of the board of Phillips Petroleum Company, suggested the time had come to do something to encourage more discovery work. Exactly two months before the Japanese surprised Pearl Harbor, he repeated the thought:

"The United States is approaching a shortage of crude oil and of petroleum products because of the decrease in discovery of new reserves.

"The demand for crude oil is now 20 percent larger than in 1937 and 10 percent above 1940 and is steadily rising. Meanwhile the annual rate of discovery has fallen 60 percent since 1937."

The oil business still has in reserve, however, the powerful old resource—*"Pay the drill enough—,"* which ended the prolonged period of shortage from 1915 through 1920; a period when gasolineless Sundays in 1918 were due to actual shortage of crude oil instead of transportation bottlenecks, and when, in the summer of 1920, California was rationed gasoline as the United States public is now being rationed sugar. By raising prices of crude oil sharply in 1919 and 1920, enough additional drills finally were enticed into discovery work to bring back plenty of oil.

The same plan might work again.

☆☆☆

P 094.84

Solving Carbon Dioxide Problem of Boiler Flue Gas

by W. F. Schaphorst

IF THERE is a boiler operator today who does not know the CO_2 content of flue gases from the boiler burners, it is generally safe to say that one or two conditions exist, as follows:

1. The plant is small and burns very little fuel, so that the first cost of CO_2 equipment prohibits its use.
2. The boiler operator may not be well versed in modern boiler practice and is thus not acquainted with the advantages of having the right CO_2 percentage.

There are now so many CO_2 apparatus on the market, selling at all prices, all the way from the well-known Orsat to modern electric equipment, that it is indeed a small plant that cannot afford one.

The latest device on display at the last Power Show in New York does not contain chemicals, glass, or delicate parts, small orifices, ink, pens, running water, etc. Its operating mechanism consists of a standard motor and two fans that measure the CO_2 by comparing the force exerted on one fan by flue gas moving at high velocity, to that of air moving at the same velocity. As CO_2 is 50 percent heavier than air, the difference in weight is appreciable and when magnified by traveling at a high velocity can be indicated on a dial with great accuracy.

This method does not require any delicate parts and is said to be so rugged that it can be depended upon to give accurate service for years under the most severe operating conditions. It indicates the CO_2 percentage continuously. A permanent record is also made for the boiler operator or engineer. The scale is easily read from any position in front of the boiler.

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Each crankthrow actuates one scavenging air piston and accommodates a separate compressor cylinder. Fewer crankthrows mean fewer main bearings to wear and service, permit each bearing to be generously oversize. In short, G-MV is designed for heavier loads and superior performance throughout a longer life.

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Cracked Gasolines

Class Meeting No. 12

NOTE: Throughout the class proceedings, no attempt is made to distinguish the identity of the pupil speaking. When a series of remarks is made by pupils, it usually denotes an interchange of discussion among the class members themselves.

IN conjunction with the previous 11 class meetings the members were divided into 5 groups and an assignment made by the class leader. Meeting number twelve has been devoted to the flow sheets and explanation of the plants designed by the groups.

The assignment as made by the leader is as follows:

A flow sheet should be made by each group making use of as many of the various cracking and allied processes as you may deem practicable. Assume a crude run of 300,000 bbl. per month of Oklahoma City oil, gravity 38.0. Yields from the crude operation may be assumed as follows:

	Percent:
250 E.P. straight-run gasoline—70 A.P.I. gravity	15.0
Naphtha to crack—50 A.P.I. gravity	10.0
Kerosine to crack—43 A.P.I. gravity	5.0
Kerosine sales—43 A.P.I. gravity	5.0
No. 1 fuel—sales—40 A.P.I. gravity	8.0
No. 3 fuel and Diesel—37 A.P.I. gravity	3.0
Topped crude	53.8
Gas	0.2

I did not make a calculation as to the gravity of the topped crude. This can readily be determined by the specific gravity method. The yields should be carried through step by step so as to arrive at an ultimate that will represent a maximum of 82-octane gasoline, the octane to be determined by the A.S.T.M. Motor Method.

It is realized that hydrogenation might be employed in order to bring the coke to liquid; however, for the purposes of this study, it is suggested that hydrogenation not be employed due to its economic limitations. Tetraethyl lead used should not exceed 1.5 cc. per gal. To simplify the study, it may be assumed that all of the gasoline will be of one quality, as previously described. It is suggested that probable temperatures and pressures be shown; however, time factors need not be considered as the purpose of the present study is to fix the processes in our minds rather than to establish details of design. You likely will not desire to use all of the following processes suggested for consideration: gas conversion, cracking, reforming, hydroforming, polymerization, alkylation, and aromatization.

Any of the foregoing processes may be thermal or catalytic; however, the process adopted should be specifically identified. Treating methods may be disregarded with the presumption that the most favorable method will be employed.

It is suggested that each group be prepared to offer a statement of yields, amount of lead required for the gasoline, and a summary listing the processes employed, all of these to be put on the blackboard by groups.

Leader: How many gasoline yields are represented? Group No. 1, do you have a gasoline yield established?

Pupil: Yes, 67.4 percent.

Leader: Group No. 2, did you establish one?

Pupil: Yes, 66.1 percent.

Leader: Group No. 3?

Pupil: We are slightly behind that point.

Leader: Did you get a figure?

Pupil: No.

Leader: No. 4?

Pupil: We have a figure of 71, but we will take 68.

Pupil: 63.2 percent is the one Group 5 figured out.

Leader: Did you establish the lead required?

Pupil: I will guarantee it to be less than 1.5 cc.

Leader: No. 2?

Pupil: 0.3 cc.

Leader: No. 4?

Pupil: 1.5 cc.

Pupil: Ours is 1.28, I believe (for Group 5).

Leader: This summarizes as follows:

	No. 1	*No. 2*	*No. 4*	*No. 5*
Gasoline yield	67.4	66.1	68.0	63.2
Lead required	—	0.3	1.5	1.28

Pupil: We arrived at the total average octane of gasoline produced and estimated what it would take to bring it to 82 octane.

Leader: Group No. 1, will you explain your process? (See flow sheet on page 31 of the January issue of *The Petroleum Engineer.*)

Pupil: We didn't get far enough to figure out our total lead requirements, but we came up with a unit that is going to require two and one-half to three million dollars investment, which would utilize existing cracking equipment such as we have. We started off with 15 percent straight run gasoline of 250 endpoint with an octane number of approximately 60 Motor Method. This resulted in 67.4 percent gasoline, which we expect to make, 82 octane, with the addition of not more than 1.50 cc. of lead per gal. That is the percentage based on original charge to the unit. We didn't intend to do any further processing of the straight-run gasoline due to the fact that the lead sensitivity is very good and has a good endpoint that would blend very well with some other gasolines.

Leader: Do you have the number of cc. of lead that you would use?

Pupil: These octanes I have shown were without the addition of lead. To try and tie-in the units that we have designed, we have more or less jumbled figures, and we had 10 percent naphtha of 50.-deg. A.P.I. We intended to take that through a naphtha reversion or polyform unit as shown in current periodicals recently. Yields would run 86 percent gasoline on the charge to that unit and the gasoline on that unit would have an octane number of 75 by Motor Method. To the naphtha charge you must add C_3-C_4 fractions from other units. We intended to get these from the debutanizer and the catalytic gas oil cracking unit. This catalytic gas oil cracking unit has a

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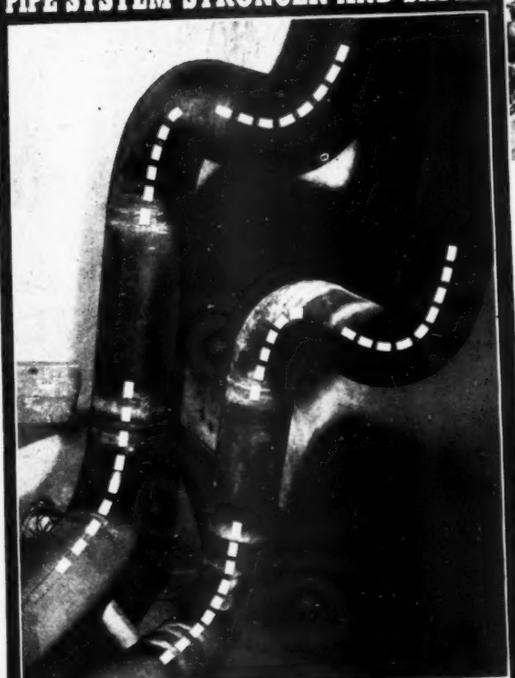

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stabilizer that takes gas from all the cracking units and we will take C_3 and C_4 fractions from this unit and also from the debutanizer, which we will place on the final stream and put it up to the naphtha reversion unit, at which point we will derive this [illegible] yield of high octane gasoline. We will also make fuel oil of approximately 8 percent. That 8 percent is added to our thermal cracking charge, which includes catalytic recycle gas oil. We had 10 percent yield of kerosine on crude unit, 5 percent was for sales and 5 percent for cracking. Due to the small quantity of kerosine available for cracking, we thought it would be best to blend that in with the gas oil that is going to our catalytic gas oil cracking unit. The 5 percent figured on the monthly basis would only be 15,000 bbl., and it would not be economical to build a unit to handle this one product separately. Of our original charge 53.8 percent was to be topped crude bottoms of 26-deg. A.P.I. We put this through a reduced crude fractionating section and it nets a yield of 55 percent gas oil of 28-deg. A.P.I. and 45 percent topped crude of 18-deg. A.P.I. We intended to treat these two products separately in order to get the highest ultimate yield possible. The 45 percent 18-deg. A.P.I. reduced crude was to go to the recycle delayed coking unit. This would have a temperature of about 895°F. furnace outlet, and pressures of about 250 lb. on the inlet and 50 lb. on the outlet. We should expect 25 percent gasoline yield with an octane number of 63 Motor Method. This 25 percent gasoline we would take through the debutanizer and our gas oil would be combined with 55 percent of 28-deg. A.P.I. gas oil from the crude. The gas oil and the kerosine mixture is charged to the catalytic gas oil cracking unit. We would expect 48 percent gasoline yield of 77 octane. We would also have about 51 percent yield of recycle gas oil. As we would like to have a once-through operation and as that recycle gas oil would be a very excellent thermal charging stock, we saw no need to recycle it. We were taking gas from this unit and also we have intended to bring the gas from our continuous thermal cracking unit back into the stabilizer; the C_3 and C_4 will be used in the naphtha reversion system. We will have dry gas for fuel. Charge for thermal gas oil cracking is 51 percent of the original charge to the catalytic units and the 8 percent fuel will be blended to charge. To have some pressure gas oil to blend off with our 3 percent straight-run Diesel fuel oil made on the atmospheric unit we made 13 percent No. 3 fuel, 60 percent gasoline, and 17 percent coke yield and the balance loss. We had also planned on taking this P.D. from the continuous thermal cracking unit back through the naphtha reversion unit. This is done to improve the octane number of the gasoline made from thermal cracking.

Pupil: But if you bring the P.D. back in that manner, it will be completely mixed with gas oil and cracked gasoline. There will be no way to separate it.

Pupil: We can stabilize it and then send it through separately.

Pupil: Is it your intention to send your entire gasoline from the thermal gas oil cracker back to the naphtha reversion unit?

Pupil: Yes.

Pupil: Then, why stabilize it? Why not just pump it all back?

Pupil: Probably that should be done.

Pupil: Also it would be cheaper to put it in directly without the expense of stabilizing.

Leader: Isn't this cracked gasoline very difficult to reform?

Pupil: Extremely difficult.

Pupil: You are operating your naphtha reversion unit so that you would get some cracking of gasoline produced from thermal cracking.

Pupil: You may get some, but you will get a considerable gas loss. Would you apply 86 percent break-up against the entire charge?

Pupil: Yes, we figured the entire charge going into the naphtha reversion unit. In this particular instance we figured we would have 49,841 bbl. of gasoline and we added that to the gasoline production of all other units and put that through the naphtha reversion unit. We are taking a high gas loss, but hope to gain octane number.

Leader: Is this polyform gasoline very lead sensitive?

Pupil: Yes.

Pupil: You used the catalytic cracking unit to get your octane?

Pupil: Yes, the blending value of the gasoline would be over 90.

Leader: How much gasoline did you show from delayed coking?

Pupil: We came out with 18,158 bbl. per month with an octane number of 63. That went to the debutanizer.

Pupil: Wouldn't it be more desirable to charge the 18,158 bbl. of gasoline from the delayed coking units to the naphtha reversion unit rather than the gasoline from the thermal cracking unit? This material is only 63-octane number as compared with about 68- to 70-octane on the thermal gas oil cracker. This material does not need stabilizing before charging to the naphtha reversion unit.

Pupil: You are correct, but this (referring to the chart) was the way we set our unit up.

Leader: What kind of lead response would that have?

Pupil: I didn't think it would have very good lead sensitivity, but we had 71,773 bbl. per month of gasoline off our catalytic cracking unit with an octane number of 77, and it would require very little lead.

Leader: In the book, there was cited an instance of using 0.7 to 0.65 cc. lead per gal. for a catalytically cracked gasoline. Any other questions?

Pupil: It takes 1 cc. per gal. to bring that up to 82.5-octane off these catalytic cracking units. We were only figuring on the ultimate gasoline yield from a debutanizer—89.6 percent of the total charge to the unit. So we were not trying to plug the figures.

Leader: Is there any minimum for the ratio of gas added to the naphtha polyform charge?

Pupil: Yes there is. The ratio of C_3-C_4 required in order to get proper conversion is very high. The thought that occurred to me is that we have spent a tremendous sum of money; in the first place we put in a naphtha reversion unit to process 37,000 bbl. per month and to combine with this we are bringing in material that is relatively rich in unsaturates from both the thermal gas oil cracking and recycle gas oil cracking. Those are relatively rich in unsaturates and it seems that a simple combination of treatment for H_2S removal and catalytic polymerization offers better possibilities at a lower cost. If naphtha reversion is used rather than thermal reforming the outlet gas from the catalytic poly plant might be recycled with the naphtha. I do not see much hope of material improvement in the thermal gasoline through charging it to a naphtha reversion unit and there is a material loss in volume of finished gasoline.

Leader: I would express my doubts that you would get within your lead requirement.

Pupil: I don't believe we can get the help from the naphtha reversion unit planned on.

Pupil: Has any work ever been done in the matter of trying to process cracked gasoline through naphtha polyform?

Leader: Yes, I have talked to several people who could be called authorities on the subject, and they have all expressed a considerable respect for the refractory characteristics of cracked naphtha. Our own work with reforming has indicated that same situation to exist.

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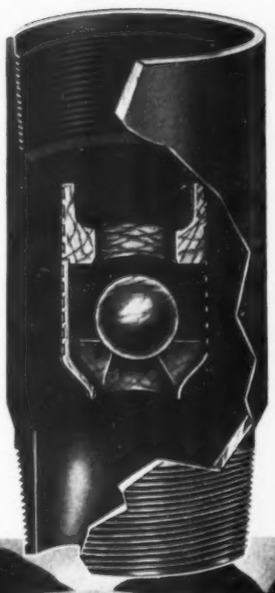

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Pupil: There seems to be a peculiar tendency in that it is quite difficult to do anything with cracked gasoline out of a thermal unit, although catalytic gas oil acts in a thermal unit somewhat the same as virgin gas oil.

Pupil: I doubt if the P. D. from the thermal cracking, which is something on which I did not find any information, would react fully to naphtha reversion. I doubt if I could get any good lead susceptibility either. It cut down on the yields, also, which is another bad feature.

Leader: That is a very interesting study, anyhow. Group No. 2, what is your proposal? (See page 32, January, 1942, issue of *The Petroleum Engineer.*)

Pupil: The method chosen for solution was the Houdry catalytic cracking process because it gave a high octane gasoline and under certain conditions a high lead sensitivity. To take care of gaseous products formed, a catalytic poly plant was used. Data was obtained from the October 30, 1940, issue of *National Petroleum News.* (See page 54, December, 1941, issue of *The Petroleum Engineer.*)

Of the monthly charge, 53.8 percent, or 161,400 bbl. of topped crude was charged to the Houdry Unit; in addition, 45,000 bbl. of heavy naphtha (47.5 gravity) was to be charged during the month. In order to cut down the yields of catalytic gas oil formed, a twice-through operation was to be substituted for the usual once-through. As catalytic gas oil is partially refractory, lower yields are obtained (30 percent of original gasoline yield, second time through) in which case a thermal cracking unit would probably need to be substituted in actual practice. Calculations were based on twice-through operation with allowance for reduced yields when running catalytic gas oil as a charging stock. When running on topped crude, and on a twice-through calculation, the following yields are obtained:

Gasoline	53.0%	80.1 O.N.,	61° Gravity
Catalytic gas oil	27.0%	—	32.7° Gravity
Gas	20.0%		
	100.0%		

Yields in bbl. are:

Gasoline	85,700 bbl.
Gas oil	43,600 bbl.
Gas converted to poly gasoline	10,000 bbl. 81 O.N.

On a charging stock of heavy naphtha, gasoline yields and O.N. are reduced, as may be seen in the following yields:

Gasoline	35.4%	77.7 O.N.,	65° Gravity
Gas oil	44.6%		42.9° Gravity
Gas	20.0%		
	100.0%		

Yields in bbl. are:

Gasoline	15,900 bbl.
Catalytic gas oil	20,100 bbl.
Gas converted to poly gasoline	2,800 bbl. 81 O.N.

The total number of barrels run through the unit per month is 296,600 bbl., which indicates a 10,000-bbl. unit (or larger) is necessary:

Topped crude: 161,400 + 161,400 × 0.391 (gas oil yield on virgin stock)	=224,600 bbl.
Heavy naphtha: 45,000 + 45,000 × 0.578	= 72,000 bbl.
	296,600 bbl.

In the blending process, catalytically cracked gasoline was assigned a blending value of 84, the catalytic poly gas was given a blending value of 104. The problem here was to bring 77.7 O.N. gasoline from the naphtha run to 82 and to bring 45,000 (15 percent of 300,000) of 250 endpoint straight-run from 60 O.N. to 82 O.N. Gasoline that could not be brought to 82 by blending was leaded.

Stock to be brought to 82 O.N.

Straight run gasoline	45,000 bbl.
Poly gas	12,800 bbl.
Gasoline from cracked topped crude	85,700 bbl.
Gasoline from heavy naphtha	15,900 bbl.
	159,400 bbl.

Blending and leading to bring O.N. to 82:

Poly gas + S. R. 12,800 + 12,800	25,600 bbl.
Cracked gasoline from topped crude + straight run 85,700 + 7,700	93,400 bbl.
Cracked gasoline from heavy naphtha 15,900 (1.3 cc. of lead)	15,900 bbl.
S. R. 24,500 bbl. (2.0 cc. lead)	24,500 bbl.
	159,400 bbl.

To determine lead necessary, the octane number was plotted against cc. of lead per gal. Average lead in cc./gal. was determined by weighted averages. This average is 0.44 cc. lead per gal.

A summary of yields for the month is as follows:

	Bbl.
Gasoline, 82 octane	159,400
Straight sales	45,000
Catalytic gas oil	63,700
	271,100

Yields in percent are:

Gasoline	53.2
Sales	16.0
Catalytic gas oil	21.2
Loss and burned as fuel	9.6

To make this unit financially successful, there would probably need to be a higher gasoline price, in recognition of the superior performance built into the product.

Leader: Yes it might tend to be a marginal producer.

Pupil: Is it the investment that is high? I came to the conclusion that the investment would not be much different.

Pupil: We didn't go into that, but we had two or three of them that we worked on, and we used all 8 different units and we came to the conclusion we could set up a Houdry Unit for about the same as all these other units.

Leader: I think the investment would be cumbersome if you cycle very much.

Leader: Group No. 3, will you present your findings? (See page 36, January, 1942, issue of *The Petroleum Engineer.*)

Pupil: We merely used a conventional catalytic unit with thermal cracker.

Leader: Do you have a Poly unit?

Pupil: Yes.

Leader: Group No. 4.

Pupil: We have a hodge-podge process — a little bit of everything. (See page 34, January, 1942, issue of *The Petroleum Engineer.*) We looked over the field and concluded that we would take a process something similar to this: Take our topped crude and run it to the delayed coking unit and from that we would take a gas yield that would eventually wind up in the Poly unit. The gasoline stream would be between 20 to 22 percent and we were rather optimistic and thought we might be able, as we were charging that type of product, to make an octane number of 68 to 70. We are going to make some gas oil off the delayed coker —about 69 to 70 percent, and charge it to the catalytic cracking unit. I don't know how catalytic cracked gas will process in the Poly unit. The probable yield of the gasoline from catalytic cracking would run about 45 percent of 80-octane that would have a little higher blending value than 100. The gas oil yield would be about 53 percent; something like 70,000 bbl., and is charged to the thermal cracking unit. The kerosine cut would be blended into the gas oil from the delayed coking unit before it goes into the catalytic cracking unit. The gasoline cut of 50 percent from the thermal unit would be 70-octane and we would get some more gas for the catalytic poly unit. From the catalytic reforming unit we expect an 80 percent yield of 76-octane gasoline. We will have some residuum from that. These residuums might be disposed of as fuel oil or we might take them back for coking. We would have a poly gasoline yield of about 10 percent of our total gasoline and it should have a blending value of approximately 100-octane. We estimated the octane of all the gasolines, then took an arithmetical average for the average final octane. We ended up with a final average gasoline of 78.7-octane; the straight-run gasoline had about a 60-octane rating, and 1.50 cc. of lead will bring that to 78; the total yield of gasoline was about

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71 percent. We didn't complete our figures on lead requirement so we aren't certain the addition of lead to 1.50 cc./gal. will make the 82-octane number.

Pupil: Why are you taking gas from the catalytic reformer back to the catalytic poly plant?

Pupil: I don't know why, but you have to dispose of it some place. You might put it to a flare.

Pupil: It contains from 89 to 98 percent hydrogen. There is not much you can work on.

Leader: That is right, under usual conditions.

Pupil: All that gas would be stabilized before it went to the poly plant to build up the C_3-C_4 unsaturates.

Leader: Any questions?

Pupil: How are they going to raise 60-octane straight-run gasoline to 78-octane.

Pupil: That figure was given us by the laboratory as being done.

Pupil: Addition of 1.50 cc. of lead will bring that straight-run up to about 78. We had some 325-endpoint straight-run and made about 59-octane and 1 cc. of lead brought it to 76.

Pupil: I would say he would not have any difficulty with 1.50 cc.; on his catalytic reforming he can expect a yield of 78 percent of 78-octane gasoline.

Leader: It is not very sensitive to lead though. Here is Group 5's process. (See page 99, February issue of *The Petroleum Engineer.*) This is not fully thought out and has several features I don't like, but it presents another picture. We have certainly been rugged individualists—we are "millionaires for a night." We started out with naphtha going to a hydro-former. There is not much literature on hydroforming, but it is catalytic reforming designed to give a split-off of hydrogen as an important reaction and the gasoline is highly aromatic. The gasoline yield is about 78 percent of 78-octane number. The gas is so lean that we just showed it going to fuel with no attempt to process it. The kerosine is charged to the catalytic cracker and with topped crude we have used the same liberty. The Houdry process uses a catalytic coking chamber for the topped crude or that might be a thermal delayed coker. If you did have, you have to worry about low octane gasoline so that is why we borrowed the Houdry setup on a relatively small unit. The gasoline yield is 45 percent; most of the remainder is a recycle gas oil. The recycle gas oil is brought up to a true vapor-phase unit and I don't like the fuel oil yield very well, but those are commercial yields and might be improved upon now. The poly unit is taken care of catalytically from all these sources. In order to establish the octane number and lead requirement we made a trial balance using for each source of gasoline the lead requirement to make 82-octane number. The latter data were taken from susceptibility curves that have been accumulated from various sources.

Lead requirement—each gasoline source to be raised to 820.N

Source	Bbl.	Susceptibility, lead cc./gal.
Straight run—60 octane	45,000	2.6
Poly—81 octane	19,200	0.5
Catalytically cracked —77.5 octane	68,430	0.7
Vapor phase cracked —78.0 octane	33,175	1.0
Hydro-forming— 78.0 octane	23,400	2.0
	189,205	1.35

This hydroforming comes out 78-octane and yet it takes about 2 cc. to increase it from 78 to 82; it has so much aromatics in it. Everybody here seems to believe in catalytic cracking, and there is one thing we may well remember about catalytic cracked gasoline—it has both a good initial octane and a good lead response when controlled to specified operating condition.

Table 17 gives some data on the yields of cracked products in the Houdry Process.

Pupil: Some of those who operate the Houdry unit are beginning to talk 430 and 440 instead of 400, because the lead susceptibility of that particular cut is still perfectly good.

Leader: I will show you the trends of the curves. The ordinate will be the octane number. The abscissa, cc. of lead per gal. of gasoline. This catalytic poly has a curve relatively flat, whereas catalytic cracking has a pronounced slope; it presumbly has isoparaffins so it responds to about what you would expect. The other types of gasoline have their characteristic curves. If you want to determine how much lead to use, just draw a straight line across to whatever octane you want to select and read it off the curve.

Pupil: Are those all taken as straight lines?

Leader: No, they are not. That is the imperfection of this blackboard drawing.

Pupil: Will you also draw on there thermally cracked gasoline?

Leader: Yes, the thermal cracking follows a line not much different in slope but actually it is greatly different as the initial octane is so much lower for the thermally cracked. (See page 57, December, 1941, issue of *The Petroleum Engineer.*)

Leader: Oh, yes, this thermal becomes very flat quite quickly.

Editor's Note: This concludes the series on cracked gasolines. Next month's installment will be the first in a series on the manufacture of lubricating oils.

☆☆☆

TABLE 17
Yields of cracked products in the Houdry Process
One pass; charging stock

Gas oils

Origin of gas oil	Mid-Continent	W. Texas-N. Mexico	E. Texas	Coastal
Charging stock				
A.P.I. Gravity	37.8	30.4	34.5	30.0
I.B.P. (°F.)	416	440	420	406
50% (°F.)	536	554	574	494
E.P. (°F.)	656	683	750	602
Cracked products				
Dry gas (per cent by wt.)	4.3	5.2	6.1	4.9
Catalyst deposit (per cent by weight)	3.3	4.0	3.2	1.0
Gasoline, at 400°F. E.P. (per cent by vol.)	44.7	41.6	44.4	50.3
Catalytic gas oil (per cent by vol.)	53.0	55.3	51.9	49.9
Liquid recovery (per cent by vol.)	97.7	96.3	96.3	100.2

Crudes

Crude	E. Texas*	E. Texas†	B Coastal*	36 A.P.I. M.C.*	36 A.P.I. M.C.‡	Lagunillas, entire crude
Charge to plant (per cent crude)	58.5	38.0	75.6	66.7	52.4	100
Tar (primary flash tower)						
Per cent vol. of crude	8.0	8.0	6.0	8.4	8.4	35.4
A.P.I. gravity	12.6	12.6	12.8	13.3	13.3	4.2
Charge to catalyst:						
Per cent vol. of crude	50.5	30.0	69.6	58.3	44.0	64.6
A.P.I. gravity	29.0	23.9	26.8	30.0	27.7	25.2
I.B.P. (°F.)	452	508	415	420	538	182
50 per cent (°F.)	690	740	615	650	711	672
E.P. (°F.)	760+	760+	760+	760+	760+	760+
Cracked products						
Dry gas (per cent by wt.)	4.5	5.1	7.0	4.0	5.4	3.8
Catalyst deposit (per cent by wt.)	5.3	5.4	4.4	3.9	3.5	4.5
Gasoline, 400° E.P. (per cent by vol.)	44.0	42.6	47.2	41.9	44.1	44.5
Catalytic gas (per cent by vol.)	54.4	53.4	49.2	57.7	54.9	54.7
Liquid recovery (per cent by vol.)	98.4	99.0	96.4	99.6	99.0	99.2

*Topped of naphtha.
†Topped of naphtha-furnace oil.
‡Topped of naphtha and kerosine.
Note: Percent of cracked products are given with reference to the charge to catalyst.
Table 17 combines Tables 65 and 66 on page 148 of Sachanen.

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Orientation of Conventionally Recovered Cores

PETROLEUM ENGINEER Exclusive Feature

A discussion of polar orientation of cores and its application in drilling operations to determine direction and degree of dip of subsurface formations

by Wallace A. Sawdon, Pacific Coast and Foreign Editor

KNOWLEDGE of the direction as well as the degree of dip of subsurface formations can be used to advantage not only for general geological purposes and the planning of drilling programs, but also to aid in the drilling of individual wells when unexpected faults or other subsurface irregularities are encountered. Polar orientation of cores has been used to determine the direction of dip for a number of years and cores are now being sent to California for orientation from many foreign countries as well as from the various oil-producing areas in the United States. Data thus provided have been utilized to locate faults in proved fields, to determine structure from wildcat wells or core holes, and to clarify unusual structural conditions that become evident only by drilling. In conjunction with directional drilling, core orientations have been used to guide a hole back on structure and through faults to production.

Polar Core Orientation

Polar core orientation is a magnetic method based on the fact that a certain amount of polarity from the earth's magnetic field has been acquired and retained by many formations. This phenomenon is especially true of formations such as sand and shale, the minerals becoming oriented when settling into beds and probably becoming further magnetized during the long period extending from the time they were laid down to the present. Utilizing this polarity of cores that have been taken in formations of this kind, the magnetic north and south of the core is determined with reference to the dip and strike as shown by the bedding planes of the core, and the true direction of the dip and strike then computed.

There are, however, many cores from formations such as pure limestones, diatomites, anhydrites, and dolomites, that show no polarity. Cores taken exclusively from such formations cannot, of course, be oriented by the polar method. In some cases, however, limestones will have shale breaks, and cores containing such shale partings will frequently have sufficient polarity to be oriented.

Probably the great majority of cores also contain some minerals that, though susceptible to magnetic fields, do not retain their polarity after being removed from the field. As formation cores usually contain various kinds of minerals, there will frequently be found varying percentages of magnetic minerals that retain the earth's polarity and varying percentages of magnetic minerals with different susceptibilities that will have no retentive powers. Some of these highly susceptible minerals, however, will temporarily pick-up a field from any magnetic influence, even from the magnets in the polar core orientation instrument when the core is being tested. Although the reaction due to this susceptibility tends to mask the true polarity of the polarized minerals in the core, the magnetic system used in the polarization instrument reacts differently to polarity and susceptibility. Polarity reacts more favorably at a greater distance from the magnets than does susceptibility so, by utilizing this fact, the undesirable elments of susceptibility are eliminated by increasing the gap between the magnets and the core being tested.

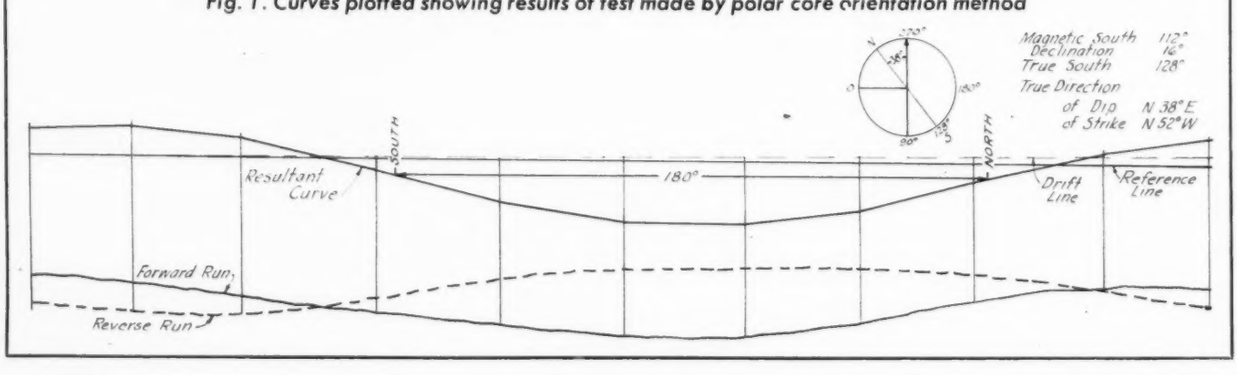
Either old or new cores can be tested by polar core orientation so long as the cores are in good condition. Fresh cores are, of course, preferable but so long as a core has not been exposed to magnetic influences sufficient to distort or destroy the residual polarity, reliable orientation can be made. Cores several years old have been tested with good results. The core must disclose a clearly defined bedding plane and in size it should be not less than 1 in. diameter and 2½ in. long. It can be taken with any type of coring equipment but its top should be marked as soon as recovered to avoid mistakes.

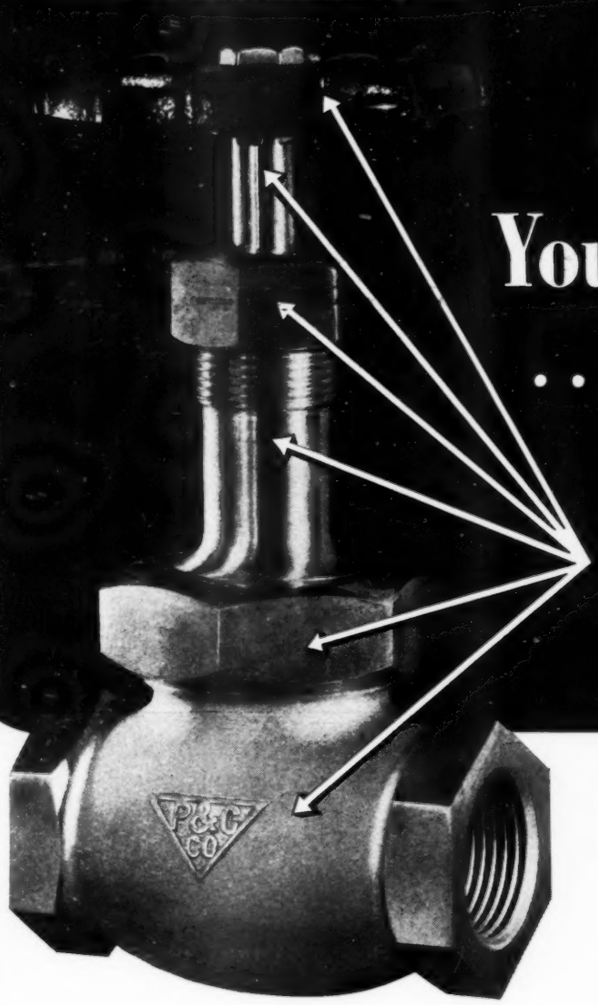
Cores that tend to disintegrate after they have been dried out can be protected by a coating of clear lacquer of vegetable compound or tightly wrapped in a cellulose acetate known as "Kodapak," which is somewhat similar to cellophane. Such cores should be washed carefully to remove mud and other foreign matter before being dipped in lacquer or wrapped in the Kodapak. This treatment does not affect the magnetic system.

Obviously, each core must be identified either by some code number or by well number with depth and other pertinent information. Of particular importance are the angle and direction of inclination of the hole if it is not vertical at the depth where the cores are taken. Without proper deviation correction the actual dip angle and direction cannot be determined.

Detailed descriptions of the equip-

Fig. 1. Curves plotted showing results of test made by polar core orientation method





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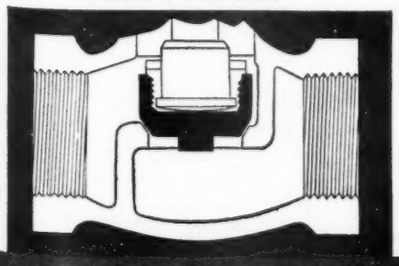
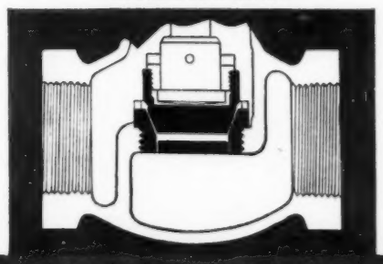
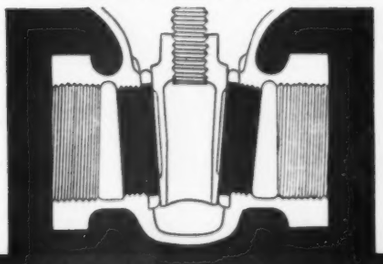


SEMI-PLUG TYPE GLOBE VALVE
REGRIND AND RENEW



BRONZE GATE VALVE
REVERSE WEDGE—RENEW



A Division of AMERICAN CHAIN & CABLE COMPANY, INC. Bridgeport, Conn.

ment used for polar core orientation have been presented in several publications.[1]

This equipment consists mainly of a magnetic system to which the core is presented in a horizontal position. The core is first ground so that the ends are parallel to each other and perpendicular to the longitudinal axis and the sides made smooth and perfectly cylindrical. Holes to accommodate driving pins of a core holder are then bored in the ends. A line representing the dip and passing through the center of the core is marked on the top with an arrow indicating the side of lowest dip. A zero line is then laid off at 90° counterclockwise from the dip line and projected down the side and across the bottom. All calculations are made with reference to this line.

The core is placed in the core holder and, after being accurately centered in direct alignment with the magnetic system, is rotated by means of a driving gear that revolves the core 360° in synchronism with a drum on which sensitized paper records by reflected light the magnetic reaction caused by the polarity of the core. This record is the solid line shown as the "forward run" in Fig. 1. The core is then reversed end for end in the core holder and rotated in the opposite direction during which the "reverse run" is recorded with a broken line. When the record curves are flat and show no resemblance to a sine curve the core is weakly polarized and often will have to be rerun with the core closer to the magnet in order to pick-up the weak field.

Interpreting the Curves

To interpret the curves an arbitrary reference line is used as the abscissa and a "resultant curve" plotted by subtracting graphically the reverse curve from the forward run as shown in Fig. 1. The purpose of this subtraction is to cancel out the effect of susceptibility. The resultant curve is then read by locating a 180° segment between the slopes of the curve, this segment being taken parallel to the abscissa. Magnetic south is at the intersection of this segment, the down slope of the curve and magnetic north being at the intersection with the up slope. As the beginning of the curve corresponds with the zero line marked on the core, the magnetic south is the number of degrees measured from the left end of the curve to the point marked "South."

In the test illustrated by Fig. 1, magnetic south is 112° from the zero line. Adding the declination of 16°, the true south is found to be at 128° from the zero line. As the zero line is 90° counterclockwise from the dip line, the true dip is N 38° E and the true strike N 52° W, as indicated on the circle representing the top of the core in Fig. 1.

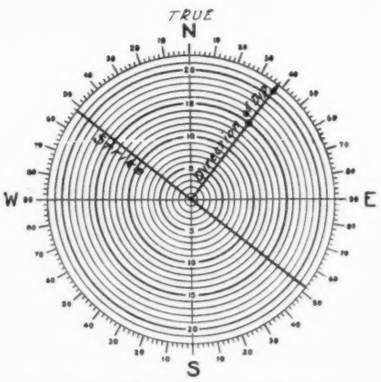


Fig. 3. Record of core orientation report. Sample from 5936 ft.; dip, 15°; direction of dip, N 38° E; strike N 52° W

In this test the hole happened to be vertical at the depth the core was taken. But even when the hole is considered reasonably vertical and the dip small it is necessary to know the inclination and direction of the hole if an accurate determination of direction and amount of dip is to be made. Assume that an inclination of 2° is known to exist at the depth the core was taken, this alone will not suffice and a directional survey would have to be taken to provide the necessary information. Two methods of deviation correction that take into consideration the magnetic vector of the earth may be applied. One utilizes a mechanical device and the other a mathematical formula.

The tops of the cores should always be marked by the operator. Should the identification of the top be lost, as in the case of old cores that may have been stored, a magnetic test can be made to determine the top. The test for top is now made on all samples received at the polar core orienting laboratory at Long Beach. This test also serves as a check against markings made by the operator. When testing for top the vertical components of residual earth's magnetic field is determined, and these identify the top of the core. Nearly every core that shows polarity in the directional test can be examined for top by this independent magnetic test.

To assure accurate determination of direction of dip in the formation being studied, three to five samples taken within a 100-ft. depth range are highly desirable. The reason is obvious, for one core alone may reflect a local flexure and not represent the average dip.

☆☆☆

[1] "Laboratory Orientation of Well Cores by Their Magnetic Polarity," by Edward D. Lynton, *Bulletin of The American Association of Petroleum Geologists*, Vol. 21, No. 5, May, 1937.

"Recent Developments in Laboratory Orientation of Cores by Their Magnetic Polarity," by Edward D. Lynton, *Geophysics*, Vol. 3, No. 2, March, 1938.

"The Mechanics of the Upside Down Core," by Edward D. Lynton, *Geophysics*, Vol. 5, No. 4, October, 1940.

"Polar Core Orientation," by Dwight C. Roberts and E. Ray Webb. Presented at the Technical Meetings, Oil World Exposition at Houston, Texas, April 24-29, 1939. Reprints of this paper have been made by Sperry-Sun Well Surveying Company, and can be procured from any district office of that company.

"Magnetic Method of Orienting Cores," by G. L. Kothny, *The Petroleum Engineer*, April, 1937.

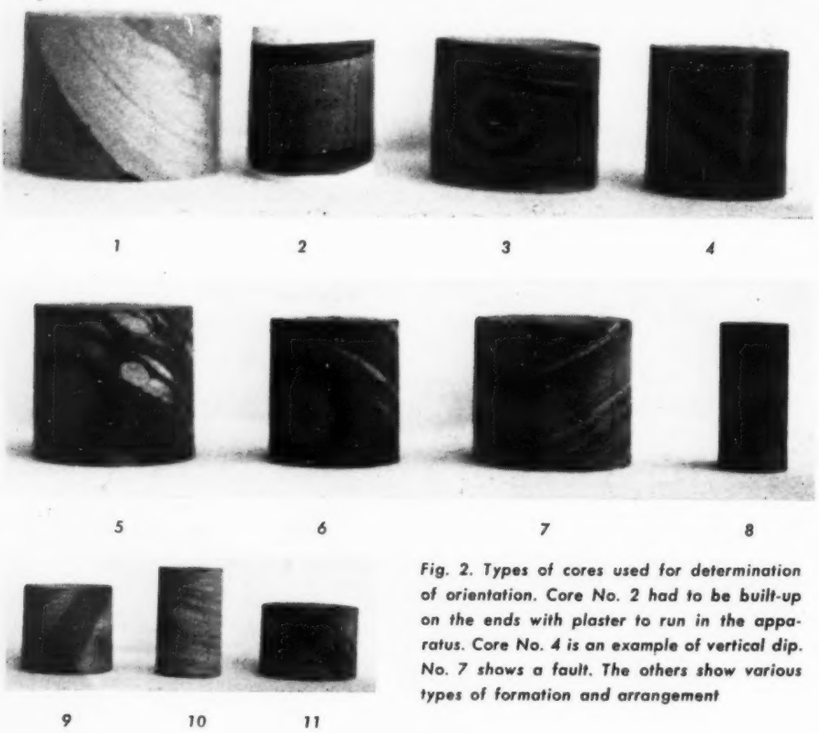
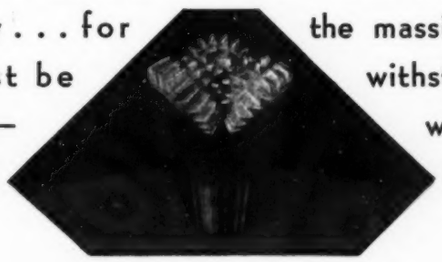


Fig. 2. Types of cores used for determination of orientation. Core No. 2 had to be built-up on the ends with plaster to run in the apparatus. Core No. 4 is an example of vertical dip. No. 7 shows a fault. The others show various types of formation and arrangement

U. S. Army 12½-Ton Tank

Built to "take it" and "dish it out"

Following the smashing attack of heavier units which breech tough positions come the light tanks and supporting infantry . . . for breeched areas must be cleaned up—maintained—widened. ¶ And in drilling for oil needed to "keep 'em rolling," Hughes Rock Bits are built to "take it." They, too, possess the massive strength required to withstand tremendous drilling weights in penetrating the toughest formations.



Hughes Tool Co., Houston, Texas

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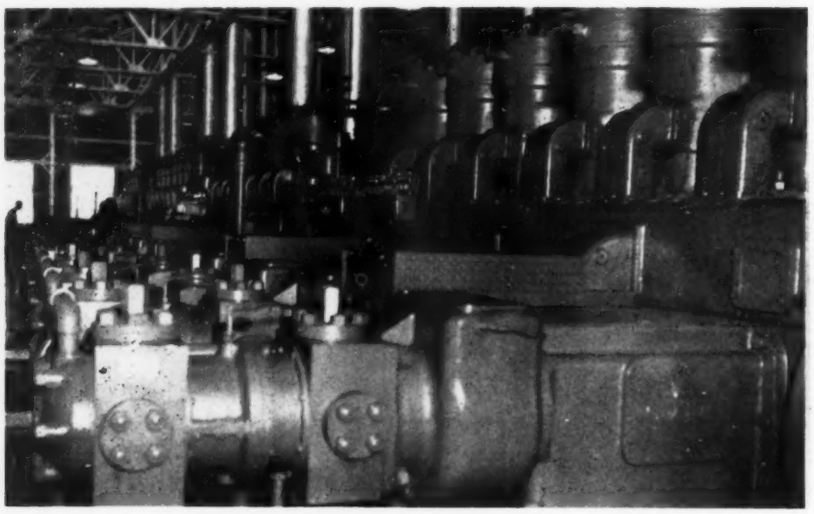
P 773.1



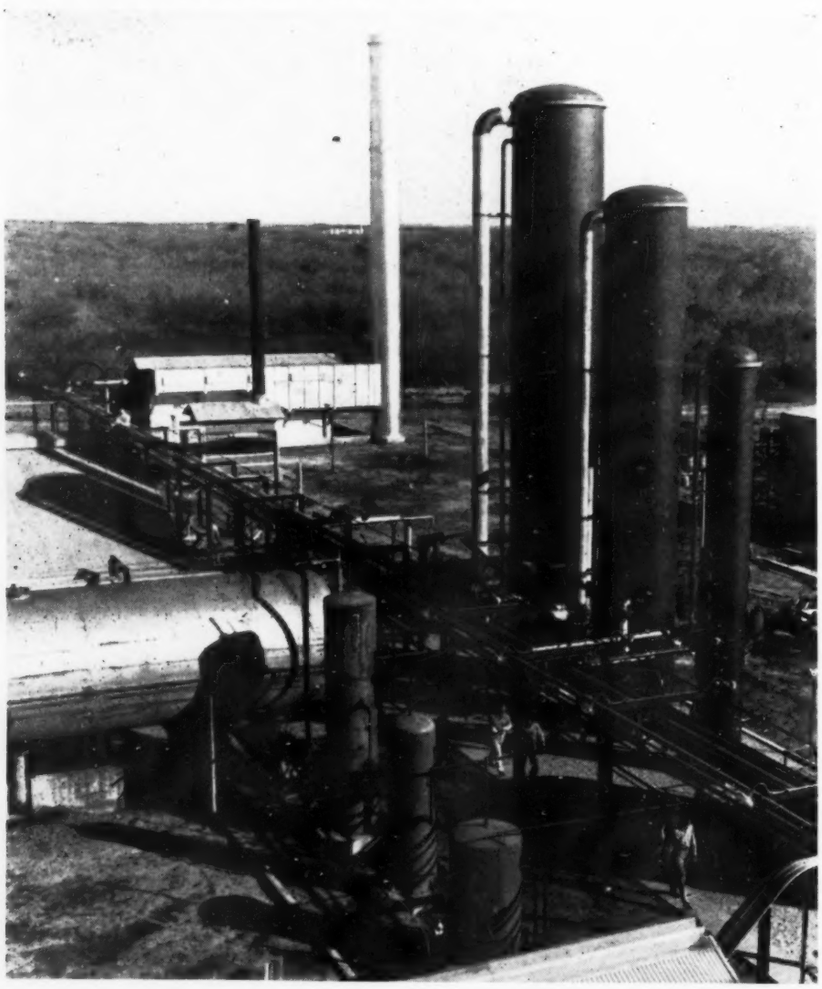
Battery of four of the right-angle type compressors, 600-hp. each

PETROLEUM ENGINEER Exclusive Feature

by C. C. Pryor
Assistant Editor

Cycling Plant Converted from Refrigeration to Absorption Process

☆ Daily capacity of plant doubled to 120,000,000 cu. ft. per day and daily distillate production increased from 1200 to 2800 bbl. — Dual gathering system permits absorption at two pressures

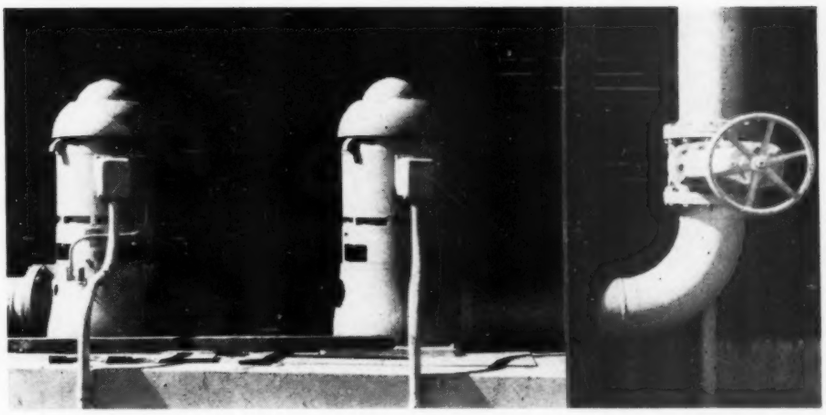


General view showing piping from cooling tower to gasoline, kerosine, and reclaimed oil stills

CONVERSION by The Chicago Corporation of the Wardner plant from a refrigeration-condensation type cycling plant processing 60,000,000 cu. ft. per day to a high-pressure oil-absorption plant processing 120,000,000 cu. ft. per day is the latest accomplishment of the corporation in the development program of Stratton field in Nueces County, Texas. This plant, one of three operated by The Chicago Corporation, was formerly owned and operated by The Corpus Christi Corporation. Other plants operated by the corporation in the field are the Coastal plant, formerly owned by The Coastal Recycling Corporation, and the Gulf Plains plant owned by The Gulf Plains Corporation.

Conversion of the plant to the new process has resulted in an output of 2800 bbl. per day.

The Wardner plant formerly processed approximately 60,000,000 cu. ft. of gas per day with a distillate production of about 1200 bbl. per day. Main operating equipment of the plant for this process consisted of cooling towers to cool incoming gas and engine jacket water, shell-and-tube heat exchangers, separators, angle-type compressors, stabilizer, weathering tanks, reflux accumulator, and brine solution, mixing, and storage tanks. Gas produced from



Deep-well-type pumps used to circulate water in one of the cooling towers

wells on the lease entered the plant from the main 8-in. gathering line at the atmospheric down-draft cooling tower. The gas was then passed to the shell-and-tube heat exchangers and further cooled by dry gas from the main separator, then dehydrated, and the distillate extracted in the separators at about 40°F. Leaving the main separator, the dry gas passed through the heat exchangers cooling the incoming gas, and to five 600-hp. angle-type compressors. The dry gas was then compressed from about 1200 lb. per sq. in. gauge to 3100 lb. per sq. in. gauge, for return to the plant injection wells.

New Equipment

The Stearns-Roger Manufacturing Company contracted for the construction of the original plant and also the building of the new oil-absorption plant. Lack of new material available for the construction of plants led engineers to utilize as much as possible the existing equipment used in the cycling plant.

The cooling capacity of the original plant was not sufficient for the new process and it was necessary to enlarge one of the cooling towers and add one completely new induced-draft tower. The new tower contains 16 bays with large draft fans powered by induction-type electric motors, 440 volts, 60 cycle, 1750 r.p.m. This tower is used for six purposes as follows: (1) cooling the vapors from the oil-reclaiming still, (2) cooling the kerosine distillate vapors from the kerosine still, (3) cooling the gasoline vapors from the gasoline still, (4) cooling the lean oil, (5) gasoline condensers, and (6) cooling the gasoline to storage.

One of the old cooling towers was used to cool the engine jacket water and the incoming gas. Four new bays were added to this tower and it is now employed entirely for the purpose of cooling engine jacket water; the remaining old tower that was used to cool the stabilizer vapors and condensed water has been converted to cool the incoming gas.

In the former process, the tube-and-shell coolers were used as gas-to-gas heat exchangers, but in the new process they are now used as water-to-gas heat exchangers for cooling part of the incoming gas.

In connection with the new process and dual gathering system, the plant has four new absorbers. Two of the absorbers operate at 2000 lb. per sq. in. gauge and two at 1500 lb. per sq. in. gauge. Absorption oil enters the top of the towers and passes through the trays counter-current to the flow of gas entering the bottom.

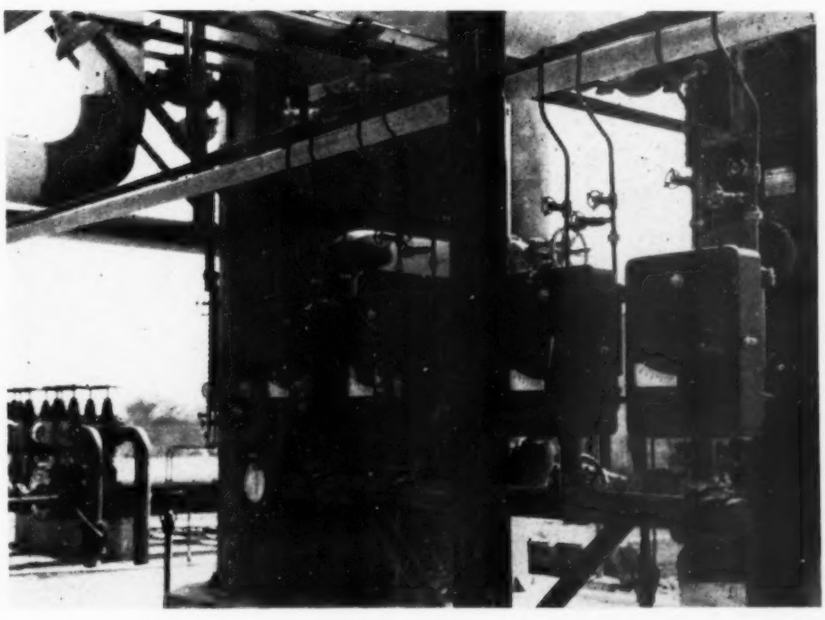
The high-pressure vent tank in the present arrangement was formerly the main separator and the existing surge tank is now employed as the low-pressure vent tank. A new intermediate-pressure vent tank has been added to this equipment.

Power for the plant is now supplied by three 3-cylinder in-line engines rated to deliver 375 hp. These engines power a-c. 3-phase, 60-cycle, 480-volt, 312-kva., generators at 360 r.p.m. The exciters on the generators are d-c. 7.5-kw., 125 volts. This new power equipment is installed in a new building and replaces the old power unit used only for lighting the plant, which consisted of a 15-kw. generator direct-connected to a 35-hp. engine.

The boiler house now contains four oil-field type boilers with 250-lb. working pressure equipped with superheaters. One new boiler has been added. Two simplex, steam-driven pumps supply the boilers with feed-water.

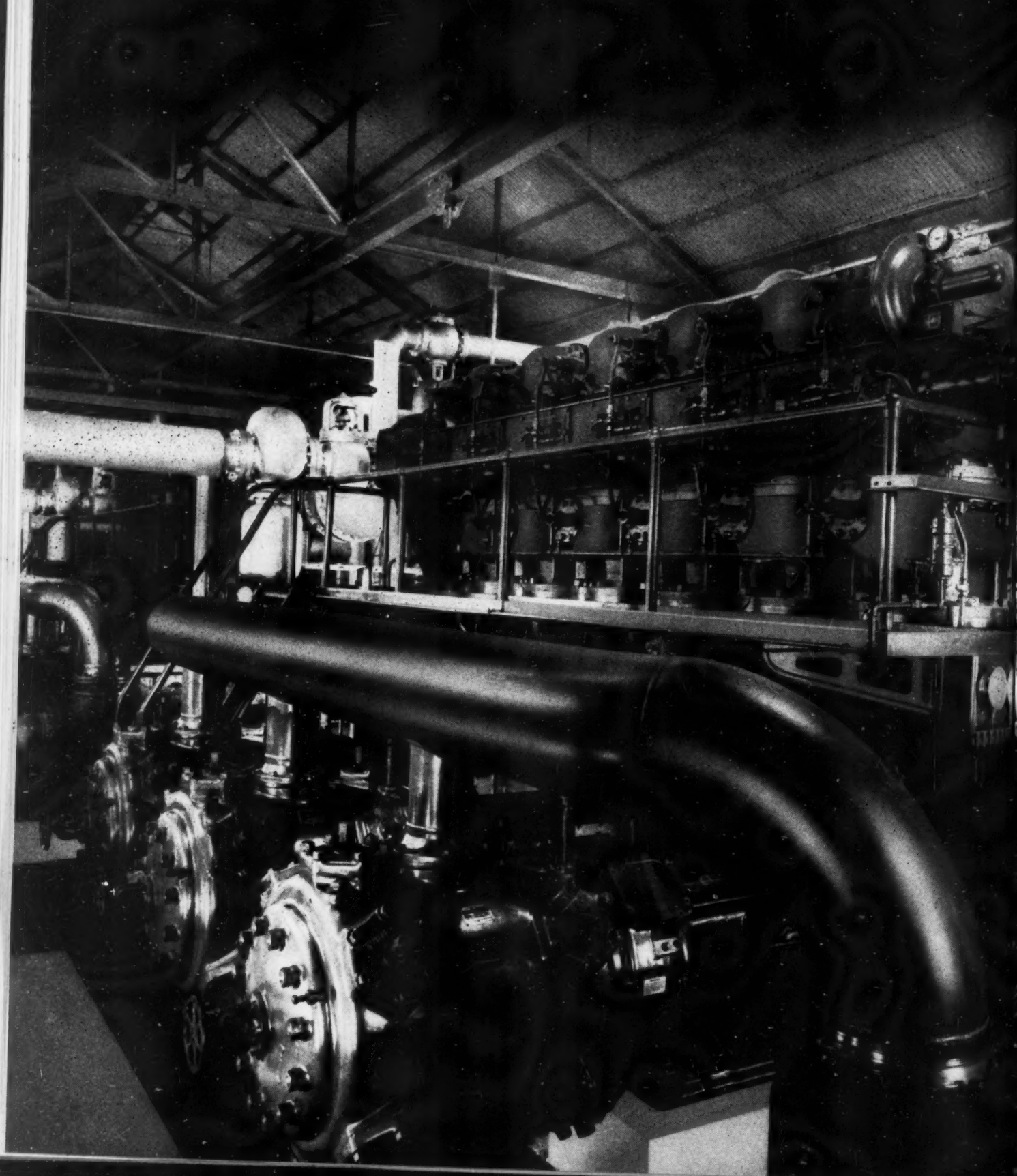
The distillation pump house contains 14 pumps for transferring absorption oil, kerosine, and gasoline. One 6 by 4 by 6 utility steam-driven pump is used for transferring absorption oil in and out of the system from storage. A 3½ by 3½ by 4 steam-driven pump is used to take the oil from the oil-reclaiming system to storage or into the absorption system. Kerosine reflux is handled by two centrifugal pumps direct-connected to electric motors. Two centrifugal pumps, direct-connected to electric motors, handle the gasoline reflux. The three high-pressure lean oil pumps have capacities of 50 gal. per min. at 2000-lb. working pressure on two pumps, whereas the third has a capacity of 100 gal. per min. at 1500-lb. working pressure. Two of the pumps are motor-driven duplex-type, sizes 2½ by 10 and the other 3¼ by 12. The two low-pressure fat oil pumps are used to take the fat oil from the low-pressure vent tank to the fat oil heater and to the

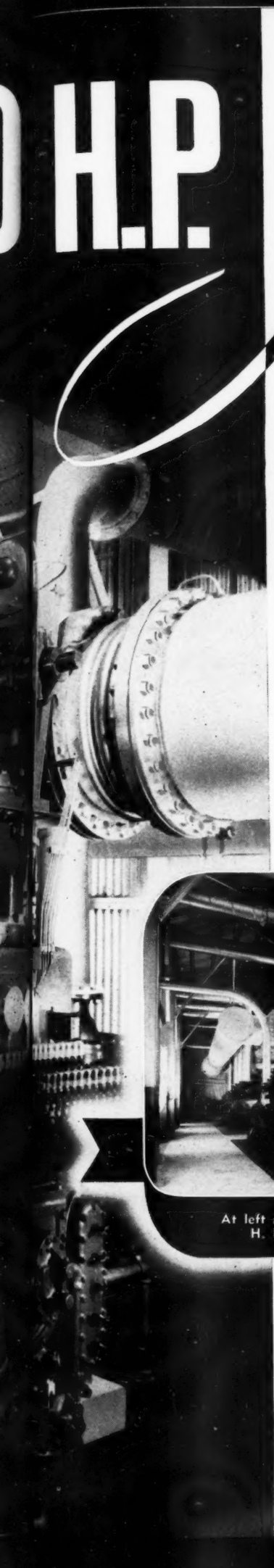
(Continued on Page 56)



Meters installed in piping below gasoline and kerosine stills

2 CLARK 3,000





0 H.P. Steam "Angles"

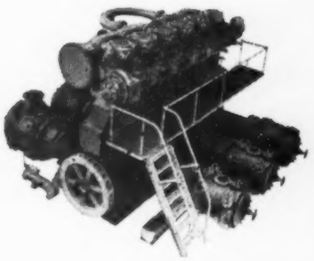
AND 3-1000 H. P. GAS-DRIVEN "ANGLES" IN THE UNION OIL COMPANY REFINERY

at Oleum, California . . . are serving in two important ways in making Hi Octane gasoline.

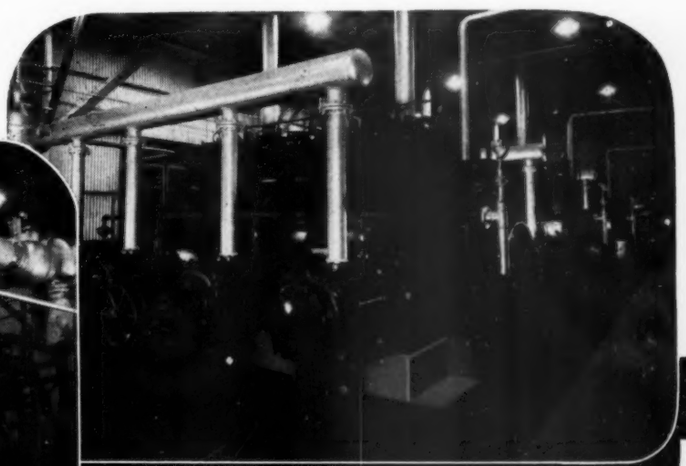
Low quality gasolines are being converted into Hi Octane gasoline by catalytic cracking. The 2 CLARK 3,000 H. P. steam-driven "Angles" furnish compressed air to burn coke, tar and asphalt from the catalyst, keeping it in efficient operation. A gas residue is then compressed by the 3 CLARK 1000 H. P. Supercharged gas-driven "Angles" to recover 8 to 15 additional gallons of highest grade gasoline per 1000 cu. ft. of residue gas.

In defense production, CLARK "Angles" are also being used for Alkylation, another new cheap method for making 100 Octane gasoline, and for producing Toluol for TNT, Artificial Rubber, Synthetic Alcohol, Synthetic Ammonia for explosives, and other important products.

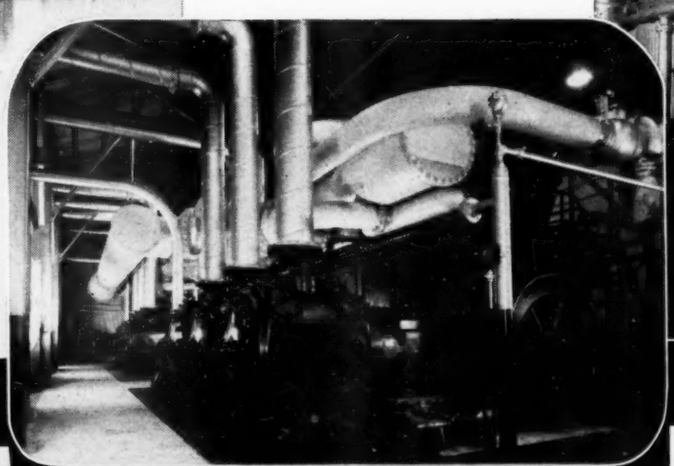
For more than 6 decades CLARK Compressors have been proving their dependability, averaging probably 98% continuous operation with few shut downs and these only after long service. Features are CLARK Super-2-Cycle Fuel Injection, no inlet or outlet valves, large bearings and few, large parts.



CLARK Steam-Driven "Angle" Compressors are offered in 3, 4, 5, 6 and 8-cylinder models ranging from 500 to 4,000 H. P. New, efficient. Ask for Bulletin 200-73.



Three CLARK 1,000 H. P. Supercharged Gas-Driven "Angles", Union Refinery



At left and above: Two views of CLARK 3,000 H. P. Steam "Angles", Union Refinery

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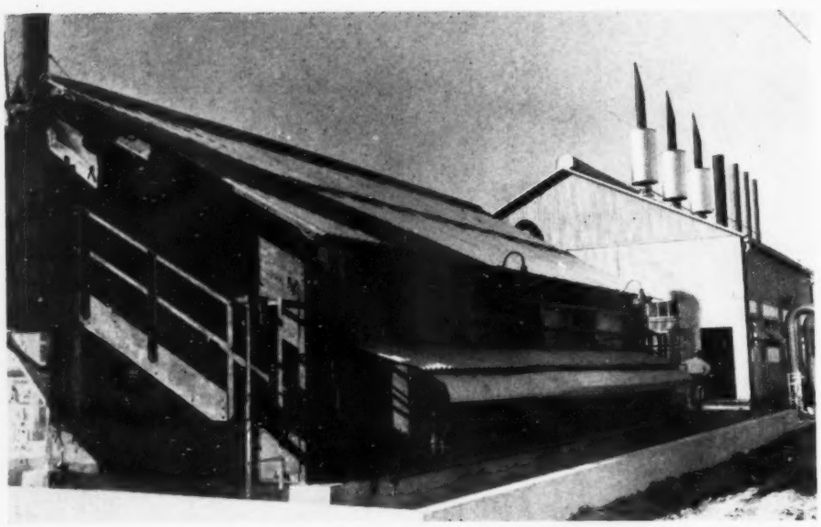


Absorption oil heater in foreground; generator house in background

(Continued from Page 53)

gasoline still. These are centrifugal pumps, direct-connected to electric motors. The two low-pressure lean oil pumps are also centrifugal and driven by direct-connected motors.

Three pumps are used in the stabilizing unit of the plant and are housed in a building near the stabilizer and absorbers. The stabilizer feed pump is 12 by 7 by 18, horizontal simplex, steam-driven, as is the stabilizer standby pump. The remaining pump is an 8 by 7 by 18 steam-driven pump used for the reflux.

Water pumps for the plant consist of two pumps direct-connected to motors that circulate 4500 gal. of engine jacket water through the cooling tower per minute. The utility pumps are two 6 by 4 by 6 duplex-type, steam-driven. There are also two vertical centrifugal pumps for circulating spray water in the engine jacket water cooling tower. Two vertical centrifugal pumps are used for circulating spray water in the gas cooling tower. Two vertical centrifugal pumps circulate spray water for condensing coils in the remaining cooling tower.

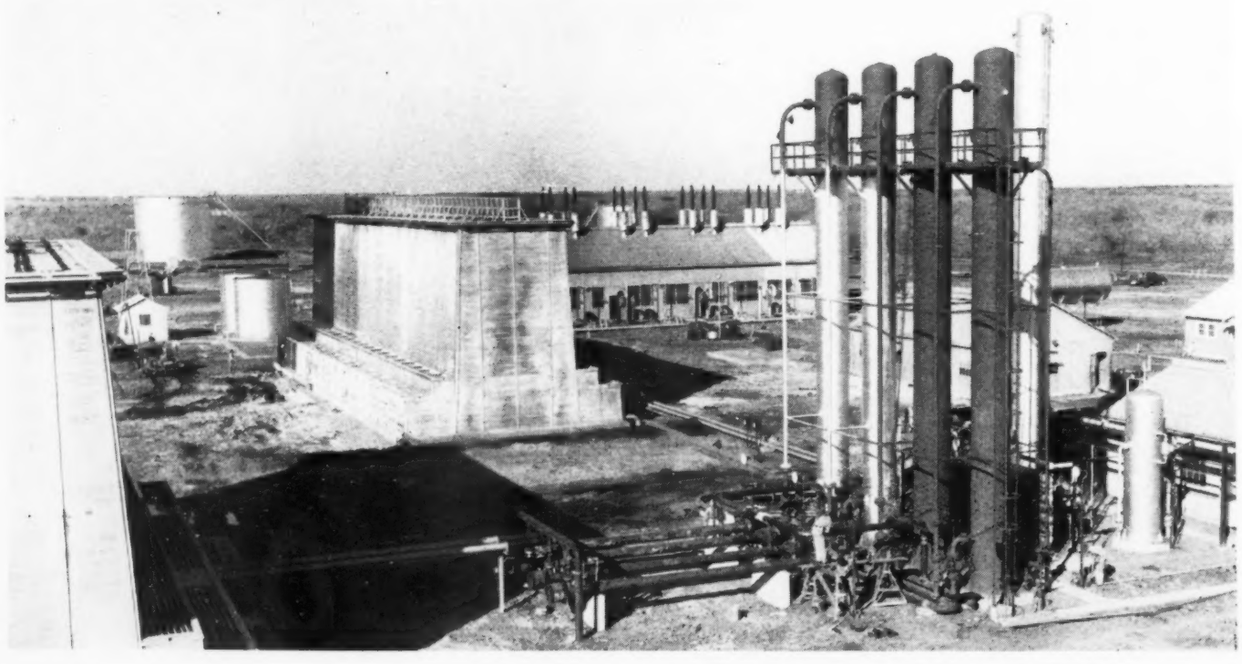
Compressors of the plant are housed in a building 120 ft. by 42 ft. Prior to conversion the plant contained only five 600-hp. compressors, angle-type and placed back-to-back. Three new compressors have been added, making a total of eight units and 4800-hp. Each unit has six 14-in. by 14-in. power cylinders with oil-cooled pistons and forged-steel compressor cylinders.

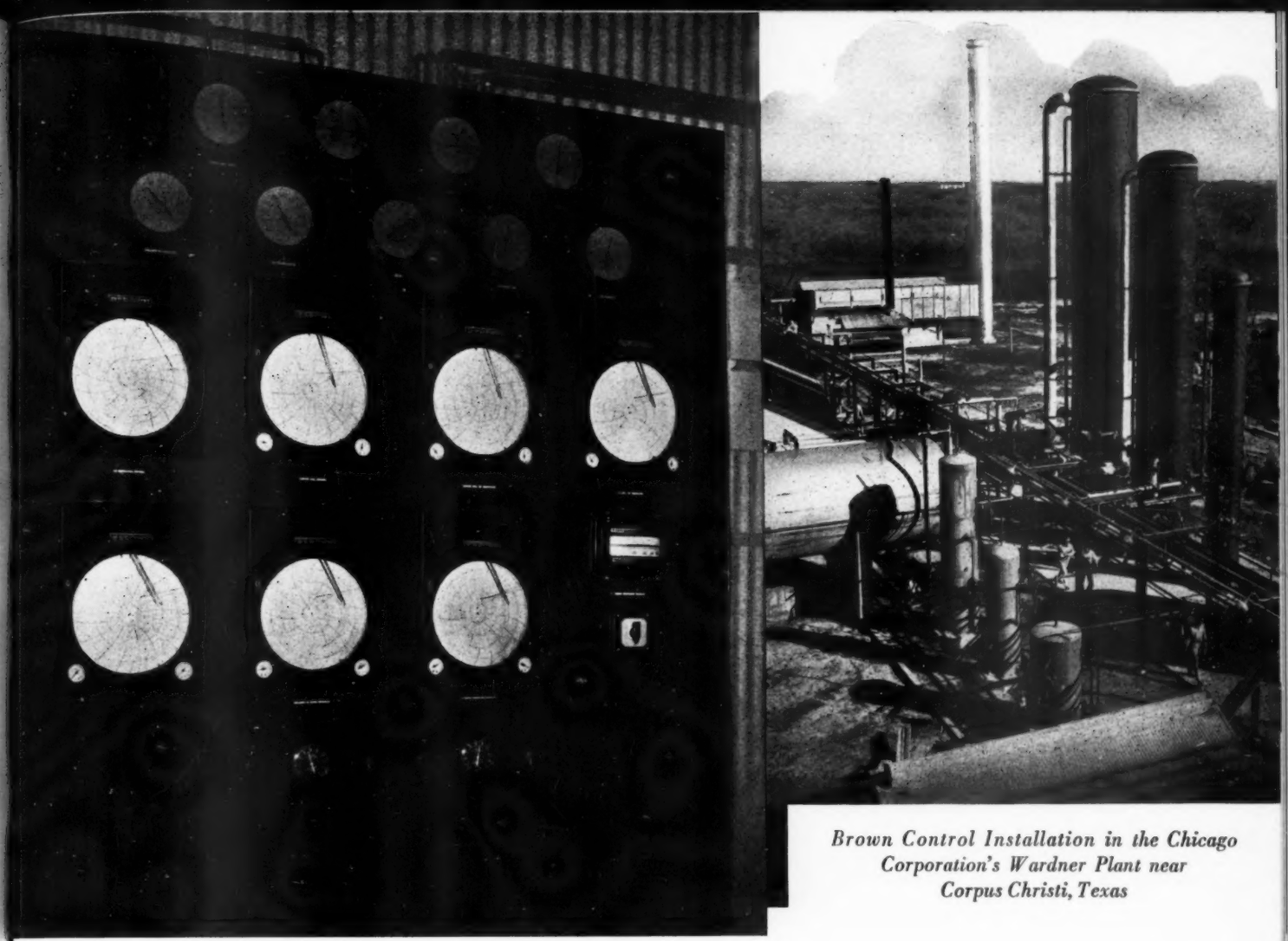
As the plant has two separate gathering systems and returns gas to the input wells at high and low pressures, the compressors are arranged in banks of four. Gas is compressed through four engines at an intake pressure of 1500 lb. per sq. in. gauge in 3½ by 14 compressor cylinders to 3000 lb. per sq. in gauge. The remaining compressors have 3¼ by 14 cylinders and compress the gas from 1700 to 4000 lb. per sq. in. gauge.

All units are equipped with force-feed lubrication. Oil to the power cylinders, scavenger cylinders, compressor cylinders, and compressor rod packing is supplied by lubricators. By means of a circulating pump, oil is pumped from the crankcase through an oil filter and oil coolers and then back through the distribution system built into the crankcase. This pump lubricates the connecting rod bearings of the engine and delivers oil to the inside of the power pistons for cooling.

Protection of the units is provided for by over-speed cutouts, low-water and oil-pressure cutouts, and excess temperature cutouts, all operating with the ignition system. In one of the accompanying photographs may be seen the air filters used in further protection of the engines. Instrument panels of the engines contain oil temperature and pressure gauges, tachometers, and

General view showing stabilizer, absorbers, cooling towers, and compressor building





Brown Control Installation in the Chicago Corporation's Wardner Plant near Corpus Christi, Texas

Eminent Performers In Boosting Aviation Gasoline Production

Proven performance and dependable field service have again made BROWN Controls the choice for the Chicago Corporation's Wardner Plant, engineered and constructed by the Stearns-Roger Manufacturing Company, Denver, Colorado.

The design of BROWN Instruments incorporates maximum obtainable power—sturdy spirals for pressure and temperature services—large area floats for measurement and control—and the positive *Air-o-Line* Control Unit for all control services.

Throughout the distillate producing areas where cycling has become the popular and practical production plan, BROWN *Air-o-Line* Control Units, non-bleed type control pilot valves, and pneumatic transmission systems have been found well-suited to these large-scale field plants, which are now contributing to our aviation gasoline output.

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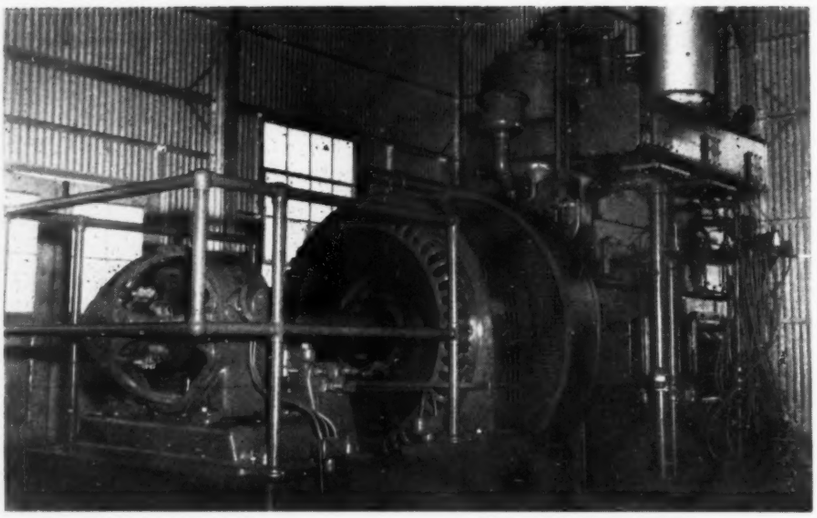
TO MEASURE AND CONTROL IS TO ECONOMIZE



One of the three generating units

six-point pyrometers indicating the exhaust temperature for each engine power cylinder.

Flow Data

The present oil absorption plant has a dual gathering system that permits absorption at two pressures. These two systems enter the plant and pass through atmospheric cooling coils where the temperature of the gas is lowered from 148°F. to 90°F. After passing through the tube-and-shell coolers the gas temperature has been lowered to 85°F., at which temperature the gas enters the absorbers. Each stream of gas enters two absorbers—two at 1500 lb. per sq. in. gauge and two at 2000 lb. per sq. in. gauge. The first residue gas from the absorbers at 90°F. enters the compressors at 92°F. and is returned to the formation at about 198°F. The absorption oil system after leaving the absorbers is now one system. Fat oil from the absorbers is vented through a high-pressure vent tank, then by use of a pilot liquid-level control is transferred to the intermediate-pressure vent tank. Gas vented from the high-pressure and intermediate-pressure tanks enters the fuel line immediately ahead of the fuel gas scrubber. After leaving the intermediate-pressure tank the rich oil is transferred to the low-pressure vent tank. The rich oil from this tank is picked-up by the rich oil pump and transported to the new heat exchangers. In these exchangers the rich oil is heated by the lean oil pumped from the bottom of the kerosine still. The rich oil is then heated in the direct-fired fat oil heater before entering the gasoline still to produce a 400 endpoint gasoline. Entering the kerosine still from the gasoline still, the partially stripped oil is denuded of the fraction with kerosine specifications. Now completely denuded of all distillate fractions, the absorption oil is cooled and returned to the absorbers by high-pressure lean oil pumps to complete the absorption cycle.

Vapors from the gasoline still are passed through condensing coils into the gasoline dewatering tank. The condensed product (raw gasoline) is charged to the stabilizer. Non-condensable gasoline vapors from the gasoline still are picked-up by a recompressor and delivered to the stabilizer. A vapor recompressor stop tank installed on the suction of the recompressor prevents liquid getting into the engine cylinders. From the stabilizer, the product (finished gasoline) passes through heat exchangers and the cooling tower and then to storage. The kerosine product passes from the kerosine still to the kerosine distillate condenser, and to an accumulator. Part of the distillate is returned to the still for reflux and the remainder is sent to storage tanks.

Reclaiming Absorption Oil

Conversion to the oil absorption process has required the addition of an oil-reclaiming unit to the plant. The absorption oil is taken from the system after it leaves the low-pressure lean oil pump. The volume of oil entering the oil-reclaiming still from the system is controlled by a hand valve in the line. Vapors from the reclaiming still pass through a reflux condenser to the oil-reclaiming reflux accumulator and then through the oil-reclaiming pump back to the absorption system. The bottoms from the oil-reclaiming still are picked-up by the reclaiming oil circulating pump and a part is returned to the storage tank for reclaimed still bottoms. The remainder of the oil passes to the reclaiming oil heater and back to the oil-reclaiming still. Data from tests run on the efficiency of the unit have revealed a high percentage of recovery of the absorption oil.

Production and Injection Wells

Gas processed by the plant is taken from wells on the Wardner lease, which at the present time is producing from five major sands, the Wardner, Guaranty-Pfluger, Upper Austin, Lower Austin, and the Bertram. Wellhead pressures range from 1700 to 3600 lb. per sq. in. gauge. In the last few months the practice of double-completing producing and injection wells has been adopted by the corporation with a marked degree of success. Production of the wells from the above-mentioned sands is obtained from depths of 5600 to 7400 ft.

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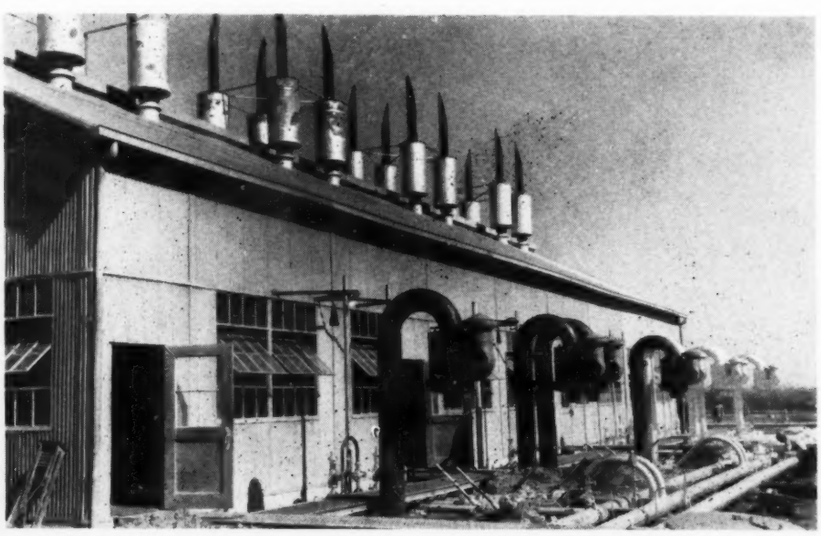

Compressor plant building showing engine exhaust silencers, air filters, and manifolding

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WYTEFACE "A" is the result of constant research. Less than thirty years ago all steel tapes were shiny—until K&E developed the well-known Keco finish to provide contrast for the numbers and graduations. In 1935 this same research produced the famous WYTEFACE line, with easy-to-read graduations marked directly on a crack-proof white surface. It is but one logical step to WYTEFACE "A" with its increased resistance to abrasion, designed particularly for oil field service!

There are K&E WYTEFACE "A" Steel Tapes in all sizes and types—in cases or on reels—for every job in the oil industry. You will find them stocked by every leading oil well supply company. Ask your dealer—or write for a catalog.

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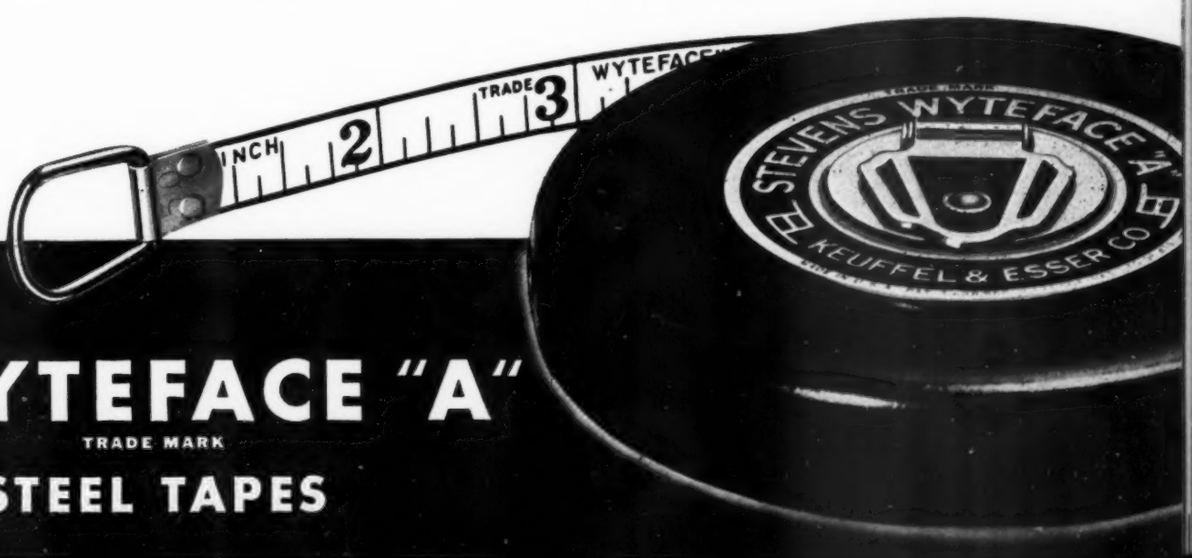

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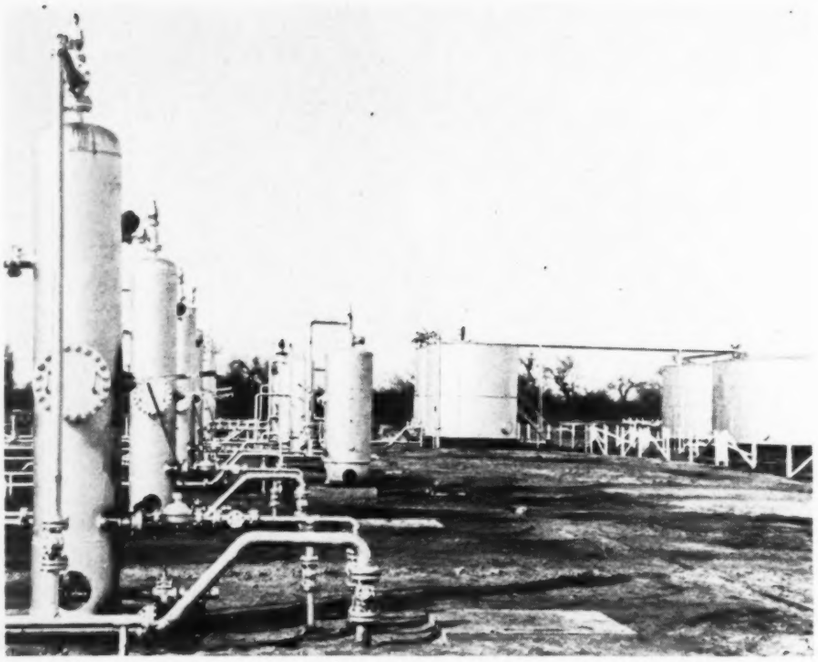


Disk-type meters measuring production from high-pressure separators at a central plant where 10 high-pressure and 2 low-pressure traps are handling the production.

PETROLEUM ENGINEER Exclusive Feature

by
Wallace A. Sawdon
Pacific Coast and Foreign Editor

Use of Meters for Measuring Production from Individual Wells

☆ **Meters for measuring oil production in the field are finding an increasingly wider range of application**

AT this time when metal and other materials are being restricted to bare necessities, the use of meters for measuring crude oil production from individual wells is being given increased consideration. Meters for this purpose have been employed in California for a number of years but their application has been accelerated during the last year or two. This fact is evidence of the ability of the various types of meters to meet the requirements of their installations because, despite their economy, they could not be justifiably employed if they did not provide accurate measurement.

The economy resulting from the use of meters consists of savings in labor, which is becoming more and more important. Meters used for well production are of the direct-reading type and the time necessary for reading is considerably less than that required to gauge a tank to measure the daily production.

Particular operating conditions will sometimes provide the opportunity for other economies through the use of oil meters. Evaporation frequently can be greatly reduced as the meter provides for handling the production in a closed pipe-line system. When a lease or particular area is operated as a unit the lead lines often can be laid to a battery and, in some cases, may be placed at a gasoline plant.

Operating Pressures

Meters for measuring well production in California are operating at pressures up to 600 lb. per sq. in., but by far the greater number of installations are handling oil at the lower pressures. The types include mainly the positive displacement, the gravimetric, and the velocity types. In the positive displacement category are the piston-type and disk-type meters. The disk-type meter is also being used for measuring power oil on hydraulic pumping installations. These meters are operated at pressures to 5000 lb. per sq. in., but this application is not for measuring the crude oil production from the well, although the power oil itself may be crude oil taken from the well. The piston-type positive displacement meter as well as inferential meters (orifice, nozzle, or venturi) are used on pipe-line operations, but this application does not apply to the measuring of well production and is not considered here. At one time some orifice meters were used for high-pressure production, but the three general types mentioned are now favored.

Piston-Type Meter

The piston-type positive-displacement meter is widely used to measure crude oil production both from pumping and flowing wells. Meters of this design are constructed with pistons moving backward and forward in cylinders, which constitute the measuring chambers. As the pistons move from end to end of the cylinders the oil that has completely filled the cylinders is discharged as the new oil is taken in. The cylinders are carefully calibrated and the amount of oil displaced at each stroke is accurately measured. Operation of the pistons is controlled by valves in a manner similar to a reciprocating pump; but in some types now widely used the pistons do their own valving through a rotary motion of the shaft, the valve being operated without the use of gears or separate mechanism. It is the oil pressure that drives the pistons, however, and not the pistons that move the oil.

Operation by flow of the oil through

Measuring low-pressure production with a single-cylinder, piston-type, positive-displacement meter

the meter is accomplished by pressures ranging from a few feet of head to considerable line pressure. The pressure, however, should not exceed that for which the meter is designed. The pressure and rate of flow do not affect the operation of the meter, but it must be remembered that a high pressure indicates a presence of gas and that the meter measures all the fluid passing through it. Corrections, therefore, must be made for the gas when it is of such volume that it cannot be taken from the oil before it is metered. When the metering is done after the oil passes through a low-pressure separator little, if any, gas is carried over with the oil and is not a problem. When some gas does carry over or when the well makes so little gas it is not passed through a trap the gas can be bypassed around the meter.

Adjustments of the piston-type meters now generally used are readily made. When the meter reading is over or under, the piston travel is increased or decreased by adjustments provided in the meter design.

Disk-Type Meter

The disk-type positive displacement meter is probably the simplest of meter designs but it must be calibrated for specific viscosities and temperatures. This type meter is being used both for high-pressure and low-pressure measurements. When used for high-pressure operation the amount of gas produced is determined and the meter is adjusted for specific conditions. As well conditions change, the calibration is corrected by an adjustment made on the outside of the meter.

Temperature correction for the oil measured by positive displacement meters is made when necessary in the same way as when gauging a tank of oil. With some designs a thermostatic control can be built into the meter but this is not being widely used in California at the present time.

Gravimetric Meters

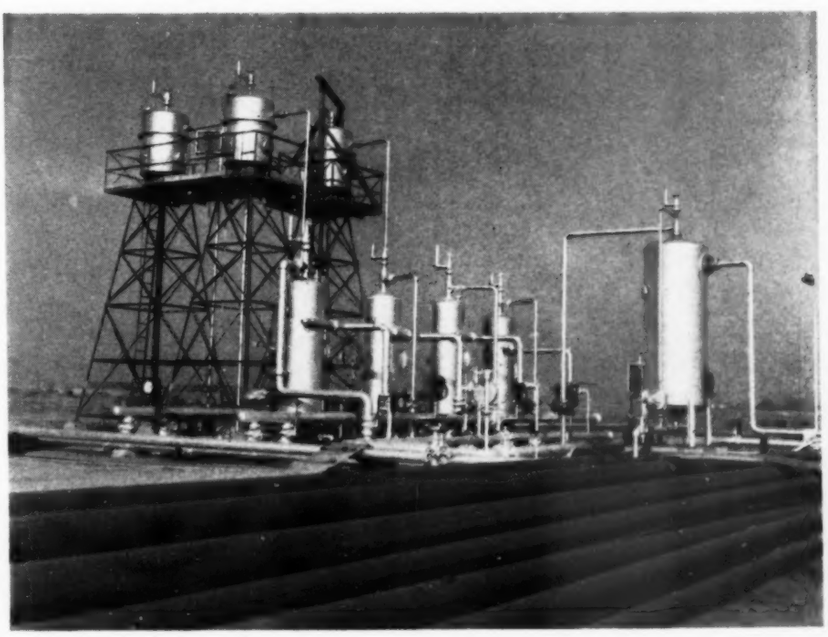
Gravimetric meters are constructed with two compartments welded back-to-back and mounted on a shaft to prevent tipping back and forth. Oil enters one compartment until the weight of the oil causes the assembly to tip and discharge the oil. This puts the other compartment into position to take the oil until the volume reaches the tipping weight when it tips and puts the emptied first compartment back into position again to receive the flow.

This design operates on the principle that the unit weight of a certain gravity of oil remains constant under all conditions and that no temperature corrections are necessary as a change in temperature, while altering the volume, does not change the weight and the measurement is automatically that of oil at the base temperature, for which the meter is calibrated. Gas contained in the oil also increases the volume but it too does not change the weight so only the oil is measured. The weight units registered by the meter are converted into barrels by correction factors applied for the gravity and water content of the oil being measured as determined from samples.

The gravimetric meter is made in either closed or open type, the open type being applicable for measuring low gravity or very viscous oil and for oil produced with quantities of sand. With the higher gravity oils the closed type prevents evaporation losses as do other types of meters. There are various designs of the closed type gravimetric meter in use but the type regarded as standard is one enclosed in a vapor-

(Continued on Page 64)

At this central station the three gravimetric meters on the platform measure the oil from individual wells of groups of eight at rotated intervals. The oil is discharged from the traps at a pressure of 55 lb. per sq. in. The larger separator to the right is a combination separator and meter.



The Conquering Kilowatts

By Lowell Thomas

HOW much power can America produce?

It took a little digging on my part to discover that right now, our power capacity exceeds that of Italy, Germany and Japan combined. Today we have fifty-five million kilowatts. Within another year American capacity will be at least sixty million kilowatts . . . sixty-four million by 1944.

Simple Terms

Those are big figures, but what do they mean, brought down to simple, visual terms? Well, one kilowatt is the same as one and one-third horsepower. That means a single kilowatt has the working strength —the actual physical energy—of 14 strong men. On an efficient treadmill they would be able to lift 500 pounds one mile straight up in the air in an hour.

Now multiply those 14 husky men (equal to one kilowatt) by the more than 100 billion kilowatt hours that were sold by power companies last year and you would have power equivalent to more than *seven hundred million men,* working forty hours a week, fifty weeks a year!

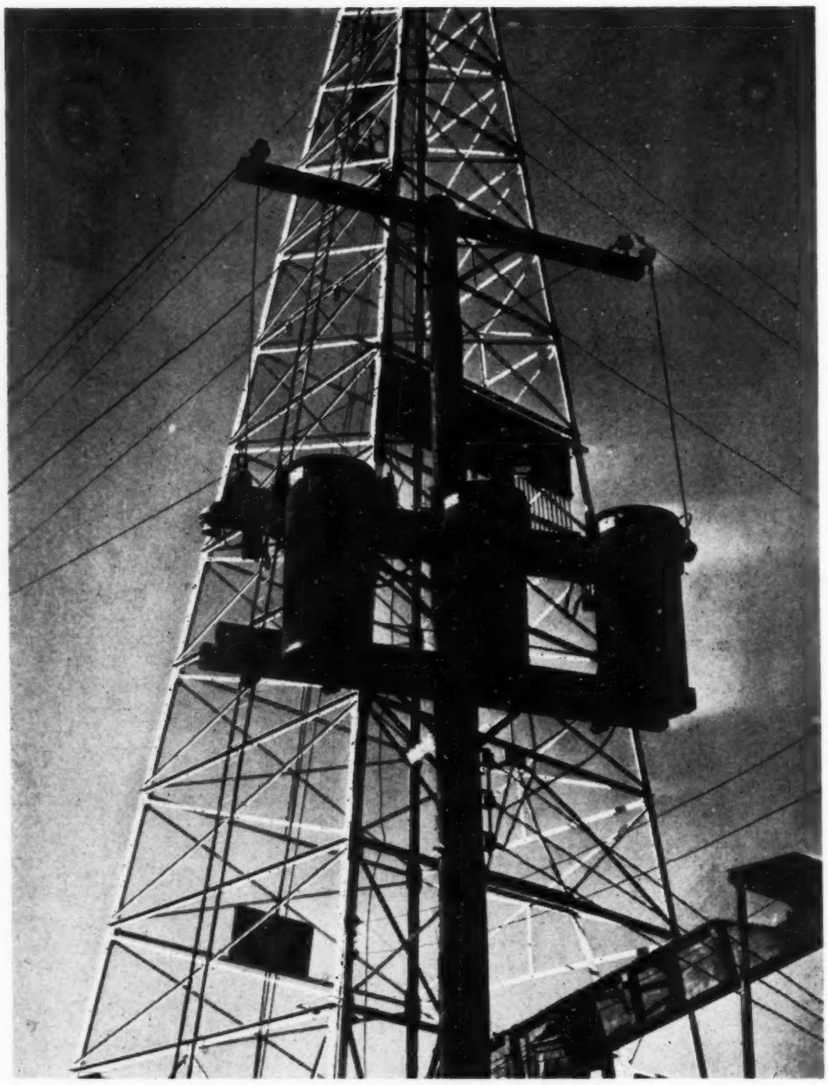
Just look what that means! Seven hundred million of these mechanical workmen are enough to provide the equivalent of more than twenty workmen for every family in America . . And you and the munitions factories can get those mechanical men to work at the snap of a *switch!* You have here, it seems to me, a beautiful example in strictly human, flesh-and-blood terms of what American power engineers have been able to do to reduce back-breaking toil — to make life more worth while for all of us — and to speed national defense production in our present emergency.

Power Enough Exists

The facts support our power company executives when they say we will have enough power to meet any immediately forseeable demand.

"Okay," says the Man in the Street, "we've got enough kilowatts — millions more than Hitler has. But how do they compare to the requirements of defense plants, and can they keep our houses and stores lighted and run our non-defense factories at the same time?"

That was what I asked Colonel H. S. Bennion, Vice-President and Managing Director of the Edison Electric Institute, which is, among innumerable other activities, the central information bureau of the Power Industry.



Not mentioned specifically in Mr. Thomas' article is how Conquering Kilowatts have gone to work for the Petroleum Industry in their gigantic task of supplying petroleum products for our war effort. Pumping, pipelining, drilling and refining are major divisions benefited by electric power.

"Speaking in general," said the Colonel, "There are plenty of kilowatts for every purpose at the present time, despite the heavy defense loads we have taken on.

"You see, the electric industry maintains in normal times a reserve generating capacity averaging about 35% over normal requirements. This is a reservoir of power that can be tapped to meet extraordinary needs.

"And there is still another reserve that can be utilized," Colonel Bennion continued. "The 'peak load' is sustained for only about four hours a day. The other twenty hours we operate at only about 45% capacity. Merely by re-adjusting working hours in a certain percentage of factories, we could thus add another ten per cent to the juice available without switching in a reserve generator or using any of our reserve fuel."

"Have most of the additions in our power capacity been in Federal plants like T.V.A., Bonneville and Grand Coulee?" I queried.

"No. Those are big plants and they're doing a swell job," the Colonel replied, "but it's our electric companies, operated under efficient American business management, who are responsible for carrying out the major part of our preparedness program. All the Federal Government power plants together supply only a little more than 7% of the nation's power — municipal plants perhaps another 5%. The great majority of power is generated by privately

owned and financed companies. Perhaps I should say publicly owned and financed, because their stockholders are numbered in millions."

That is the broad, general statistical background of Power in Defense. Adequate power now and expanding capacity for future needs.

Expansion — 300%

Whether I talked with holding company heads or operating company executives, I got the same quietly confident story. I found reason for their confidence in the history of the power industry, which, in the characteristic American way, has expanded 300% in twenty years while the population has increased by but 25%.

Throughout the industry I sensed that a spirit of genuine, cheerful and competent co-operation with the government's all-out defense effort was universal.

I learned from President E. L. Shea of the North American Company and a representative of American Gas and Electric, that electric expansion programs were begun as early as 1939 in anticipation of growing needs for national defense.

Foresightedly, the industry was mobilizing its kilowatts before action started. What this means for production, and how promptly the kilowatts can be mustered, is illustrated by just one of the examples cited by President H. P. Liversidge of Philadelphia Electric.

"After nearly twenty years of idleness," said Mr. Liversidge, "Cramp's Philadelphia Shipyard prepared to re-open. The Manager phoned me, 'Can we have power in thirty days?' 'In thirty hours,' I told him, 'if you need it.'"

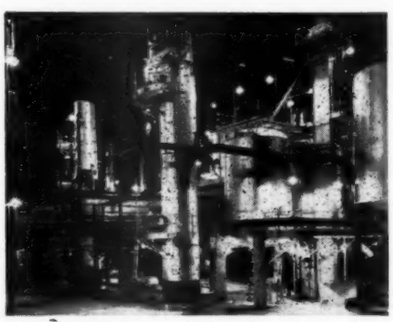
In America all our defense demand, up to now, has been super-imposed upon the normal, non-defense requirements of light and power. Utility men say that defense production can be greatly increased and still be handled without cutting the householder's lights or power for luxury items. But they foresee — and business indices already indicate — that defense production is bound to cut into non-defense work, which will lessen the civilian and commercial demand for current. This means that the strain on power resources will be in that degree lessened. "Either way," said a power engineer, "the conquering kilowatts will march on."

Here is an industry that was really ready for national defense. Electric power is now driving 86% of the factory wheels of America. And almost nine-tenths of this vast power mechanism was built and operated by private enterprise, seeking an opportunity for profit, in the matchless American Way. In that search were developed new uses and new markets for power, new comforts and standards of living for Americans, at ever higher efficiency and with ever lower cost. Backed by the savings of millions of small investors, private industry has marshalled the peacetime kilowatt forces into an army more than adequate to America's production needs in a war-time emergency.

If the outcome of our battle for Democracy depends on power (and many believe it does) the kilowatts are already becoming Conquering Kilowatts in the service of Uncle Sam. And, as far as I can see into the future, they will *continue* their forward march until that final day when the Conquering Kilowatts of Democracy will light the blazing splendor of our Victory Parade.

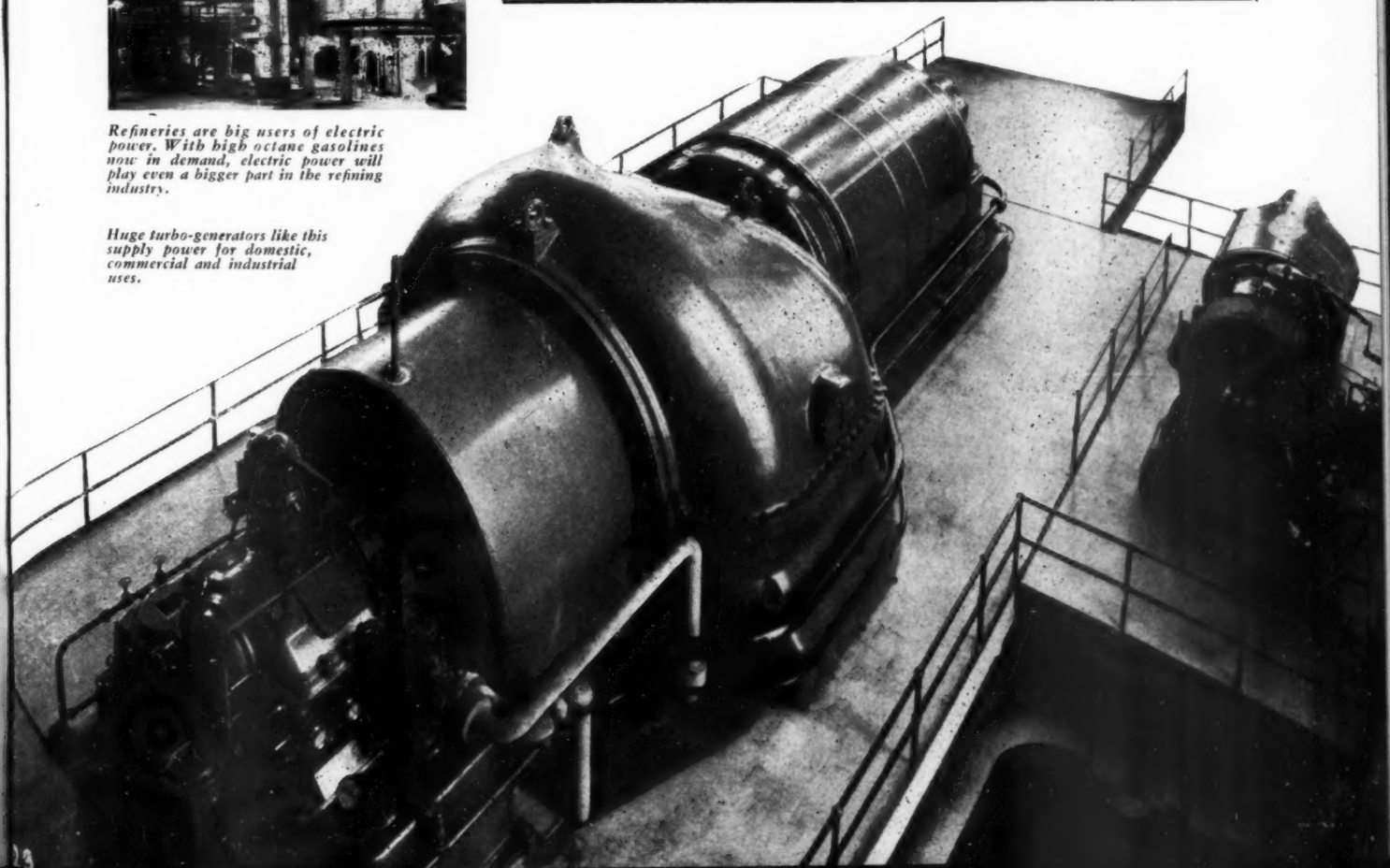
THE FOREGOING is a condensed version of an article by Lowell Thomas which appeared in the Saturday Evening Post of January 24 as one of a series of advertisements sponsored by the JOHNS-MANVILLE Company, designed to tell the American people how indispensable our basic American Industries are to our war effort. Although not mentioned specifically in Mr. Thomas' article, Utility Electric Power and its utilization by the Petroleum Industry is of extreme importance at the present time. We are proud to be able to supply Electric Power to the Petroleum Industry, which has faithfully provided Uncle Sam with adequate supplies of petroleum products so vital for victory.

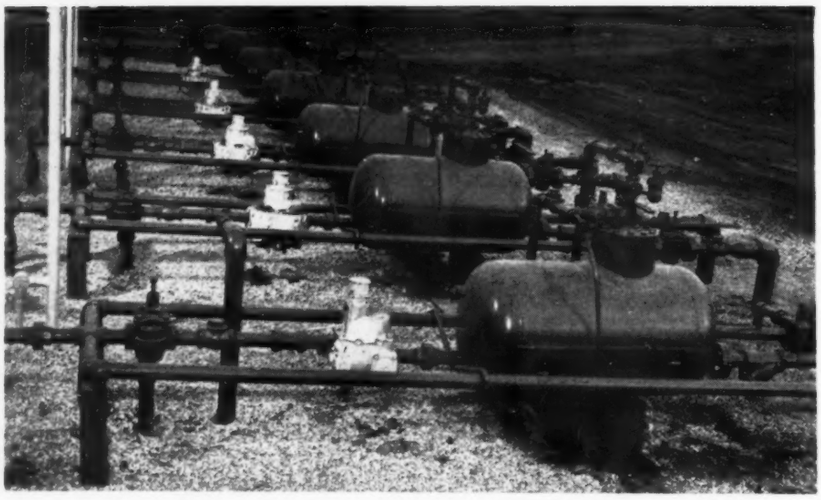
PETROLEUM ELECTRIC POWER ASSOCIATION



Refineries are big users of electric power. With high octane gasolines now in demand, electric power will play even a bigger part in the refining industry.

Huge turbo-generators like this supply power for domestic, commercial and industrial uses.





Oil measured by these piston meters first passes through the gas eliminators shown at the right

(Continued from Page 61)

tight housing having gas dome and discharge connections both for oil and gas. This is virtually a low-pressure separator and operates with liquid-level control to prevent flooding the meter as well as serving in the customary manner. To meet specific operating conditions some types of this meter have been installed in gas traps. The closed type gravimetric meters are made for pressures to 100 lb. per sq. in. but most of those now in service are for 40 lb. per sq. in. or less.

The velocity type or current meter is used for measuring high-pressure gas in several fields. These meters are placed at the high-pressure trap and operate at the trap pressure. A considerable volume of gas is contained in the fluid thus measured as the oil goes to a low-pressure separator after passing through the meter. Suitable correction coefficients are developed for the specific condition and the measurements corrected by application of coefficients to the meter reading.

Sampling of the oil actually passing through the meter is desirable and when this can be done automatically under flow conditions with drops of the fluid taken continuously at periodic intervals a representative sample of the oil that passes through the meter during a gauging period can be obtained. This provides a reliable means of determining the amount of water being produced with the oil.

Utilization of Meters

As production conditions vary extensively it is natural that there should be no standard hook-up for any type of meter. The oil should be put into the best possible condition before entering the meter and auxiliary equipment frequently must be used for this purpose. Present installations of meters range in service from the measuring of oil under pressure with high content of dissolved and entrained gas to the ideal condition of oil without gas and carrying no sand. Between these two limits are many satisfactory meter installations. The vast majority of installations, however, are those where the oil is being metered at comparatively low pressure with practically all gas (except that to be kept with the oil in a closed system designed to prevent evaporation) removed before the oil is measured.

Although low-pressure separators are supposed to remove all gas from the oil, it is frequently necessary to put a gas eliminator upstream from the meter. Gas taken off by the eliminator is generally put back into the oil stream after the oil has been measured. There are eliminators of various designs in service. Some are combination gas eliminators and sediment traps and take both the gas and sand from the oil stream before it passes through the meter. These combination traps sometimes serve as low-pressure separators when flow conditions make it feasible.

Excessive sand or other foreign matter obviously is detrimental to the meter as well as likely to cause inaccurate measurement. Even small amounts of sand, paraffin, or other matter should be removed, however, as any abrasive material entering the meter will cause wear of parts and in many instances may induce sticking of the internal mechanism. Some meters are equipped with strainers built integral with the meter but even these are not adequate when the amount of sand carried with the oil is excessive.

It is often desirable to hold back-pressure on the oil passing through the meter, and regulators are often installed downstream. Any gas taken off by the eliminator should not be put back into the oil stream above the regulator.

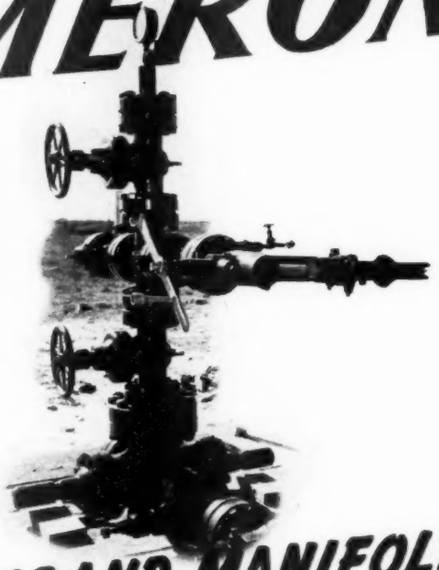
A steady rate of flow through the meter is desirable and in many installations flow is regulated by a valve on the discharge side of the meter, the valve being actuated by a lever connected with the liquid-level control valve of the separator. It is obvious that the meter should be of proper capacity for the production to be measured.

With proper hook-ups and equipment to meet the production conditions, the piston-type positive-displacement meter has operated with a high degree of accuracy and has proved its adaptability to the lower pressure installations. Measurements have been made of continuous production from individual wells and to determine well production by periodic measurements. In the former case one meter is installed for each well and serves that well exclusively; in the latter the meter is used to measure the production from several wells by means of manifolding, and either manual or automatic direction of individual well production to the meter can be employed. The automatic control of oil from several wells to a meter is naturally designed to meet specific conditions and, therefore, is somewhat exceptional.

Automatic Direction

An example of automatic direction of well production from four wells being measured by one meter is in a Los Angeles Basin field where both water and sand is pumped with the oil. The production from each well flows into its own combination separator and scrubber where the gas, water, and sand are removed. By means of magnetic selector valves and an electrically driven and controlled centrifugal pump, the oil from each trap is directed through the meter when it is ready for discharge, only one combination separator-scrubber unit discharging at a time and passing its oil through the meter. The meter has four registers, one for each well. As the automatically controlled valve opens to permit the oil from one unit to enter the line to the meter, a solenoid in the meter actuates a lever that, through gears, causes the register for that particular well to go into service and record the measurement of oil from that well. When the oil in one unit has been discharged, the line from it to the meter is closed by a float switch and the next unit can discharge as soon as the oil in it has reached its proper level. No two units

CAMERON



FLOW WINGS AND MANIFOLDS

The new Cameron Flow Wings and Flow Manifolds for Xmas tree service combine in single units the double function of conventional wing valves and quick-change positive or adjustable flow beans. The valve section of these units permits a quick and easily operated shutoff while changing chokes without the necessity of closing any vital valves on the tree. Flow beans may be changed quickly without breaking out a single threaded or flanged connection. All parts are readily replaceable in the field without removing the assembly from the well. Their compact design saves considerable steel and while these units provide several distinct operating advantages they actually cost substantially less than conventional assembled Xmas tree flow wings.

Referring to Figure 1 at right, to change flow bean fit hexagon socket in the wrench to valve stem (1) and close valve (2) against seat (3). Spanner part of wrench is then applied to clamp screw (4), and only two turns required to release flow bean (5). New bean is clamped in place by clamp screw and valve is then opened and well is back on production. Both the valve stem and valve seat are faced with hard metal to resist cutting. Valve stem and bonnet are packed with plastic packing which may be replenished under pressure. Clamp screw is packed with an asbestos ring (7) which is tightened automatically as the flow bean is clamped in place. Two-bolt union (8) obviates need for additional union in flow line. Note that the downstream end of the clamp screw is belled to reduce turbulence and cutting. Three types of flow beans are interchangeable in this unit: (1) the "proration" bean illustrated in the flow wing; (2) the adjustable flow bean illustrated in Figure 2; and (3) the "production" type bean which consists of a body and renewable stellite orifice disc. All of the flow beans clamp in position as shown in Figure 1.

CAMERON IRON WORKS, INC.

711 MILBY STREET HOUSTON, TEXAS

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California: The Howard Supply Co., Los Angeles
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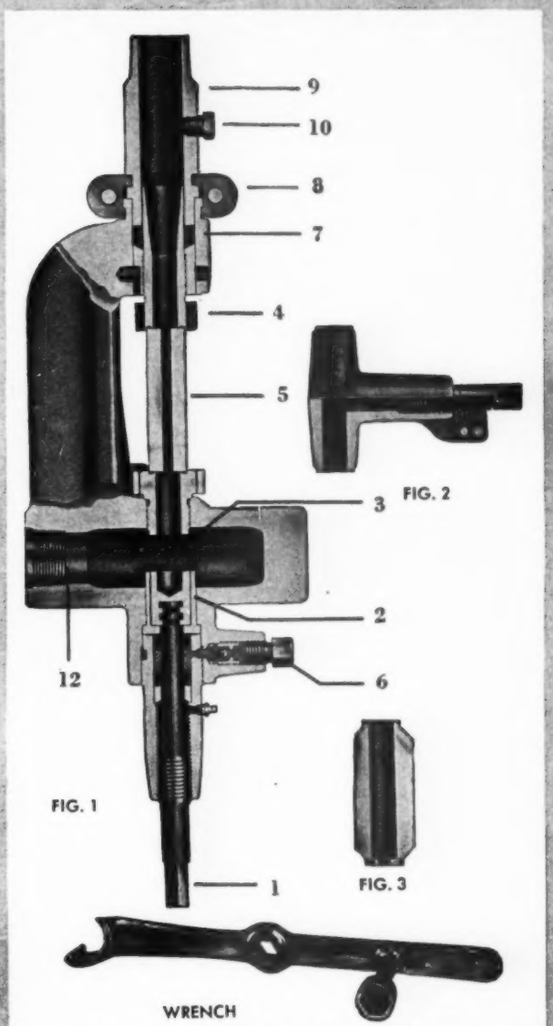


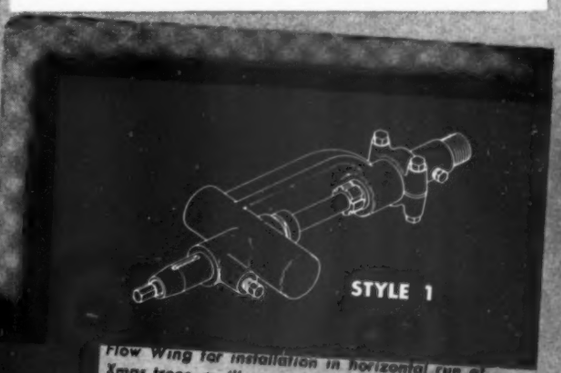
FIG. 1

FIG. 3

FIG. 2

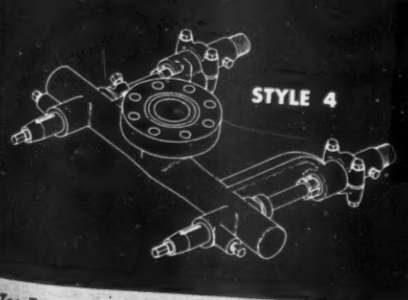
WRENCH

1. Valve Stem; 2. Valve; 3. Valve Seat; 4. Clamp Screw; 5. Flow Bean; 6. Packing Feed Screw; 7. Clamp Screw Packing; 8. Two-bolt Union; 7. Outlet Connection; 10. Bleeder Connection; 12. Inlet Connection.



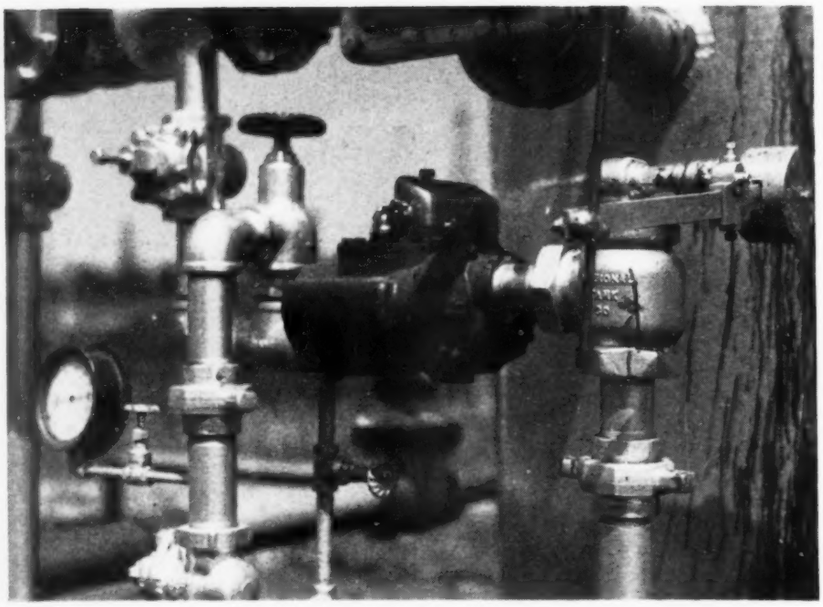
Flow Wing for installation in horizontal run of Xmas trees, as illustrated in photograph above.

Cross Type Flow Manifold for installation in vertical run of Xmas trees.



Tee Type Flow Manifold for installation in horizontal run of Xmas trees.

Tee Type Flow Wing for installation in vertical run of Xmas trees.



This piston-type positive-displacement meter is taking the oil directly from the separator, which is removing all the gas from the stream

can discharge at the same time and sufficient oil capacity is provided in the separator-scrubbers to allow for any delay in discharge due to one of the other units being on the line. In certain more recent installations the meter is equipped with eight registers and thus can be utilized for measuring the individual production from eight wells.

In one of the deep fields of the San Joaquin Valley the flow from each well passes through a high-pressure separator installed at the well and from there the oil flows to a low-pressure battery situated at a gasoline plant. The lease will eventually have 32 wells and low-pressure separation will be accomplished with five traps. Each group of eight wells will have a separator and meter for measuring individual wells at periodic intervals, the fifth separator, of larger size and equipped with its own meter, taking the oil from the wells not being metered individually. Three of the separators with meters for individual well metering are now in service and the fourth will be installed when the rest of the wells are completed. This arrangement provides for metering each well every eighth day, or every fourth day if 12-hour gauges are used.

In many cases when oil from wells on a lease is piped to a central station to save gathering equipment, low-pressure separators are provided for the production from each well and a meter installed at each trap. This, of course, permits continuous metering of the oil from individual wells.

Accuracy

When the accuracy of meters is considered there is always the tendency to compare metering with the gauging of tanks. If oil at relatively low pressure is properly prepared and excess gas removed before entering the meter it appears that accuracy of measurement is fully as great as with tank gauging. It must be remembered that the personal element enters into tank gauging and that content of the tank depends on accuracy of strapping. In gauging, the error due to reading varies inversely with the vertical distance of the volume of oil measured and a ¼-in. error in gauging 2 ft. of oil is considerably more than when gauging 10 ft. Gauging errors tend to be compensating, but so do metering errors. It has been found that results of metering approach closer to total accuracy the longer the period of measurement. At one lease in a Los Angeles Basin field where several interests are involved the oil is measured by a meter at each well. The sum of individual productions from all the wells thus metered during the last two years has been so close to the gauge taken on the storage tanks from which the oil goes to the pipe line that no question has ever been raised by any of the interested parties. The production from these particular wells passes through a combination gas eliminator and sediment trap and the gas taken from the stream before metering is put back into the line after passing the meter.

One high-pressure meter installation in a field in the San Joaquin Valley provides for the elimination not only of individual well gauging tanks, but also of most of the low-pressure separators. The wells flow into 10 high-pressure separators at 475 to 500 lb. per sq. in. pressure and the oil discharge from these separators is measured by meters placed between the separator and the oil control valve. The gas not taken off by the high-pressure separators naturally passes through the meters and the percentage of this gas is determined after it is taken off by low-pressure traps that handle all production. The over-registration of the meters due to this gas is taken care of by a chain gear that drives the counter so that only the amount of oil is recorded. When the gas-oil ratio changes the meters are adjusted to take care of the gas then being produced with the oil. The oil production is approximately 300 bbl. per day and the meters have maintained an accuracy within 1.5 percent.

Conclusion

A complete discussion of the theory of oil flow through meters of various types, the effect of viscosity, temperature, slippage, etc., cannot be given within the scope of this article.[1] Metering of well production has been done successfully in California and installations have met the demands of both accuracy and economy. Actual percentage of errors vary and the allowable errors are governed by the purpose of metering. For low-pressure installations under average conditions the measurements are frequently kept below 0.5 percent. Whether metering under conditions adaptable to the use of meters is more nearly accurate than tank gauging is still a question, but, as meters can readily be checked from time to time, there appears to be no reason why they cannot be relied upon.

In high-pressure installations there is still the correction factor to be considered because of the dissolved and entrained gas being measured with the oil and an accuracy of from 1 to 1½ percent is probably as much as can be expected. Yet the economies resulting from the use of meters on high-pressure production have been found great enough to justify their use.

[1]Interesting data on various types of meters, the theory of fluid measurement and tests made on meter performance are given in "Proceedings of the Petroleum Fluid Metering Conference" held at the University of Oklahoma, April 7 and 8, 1938. Many improvements in meter design have been made since then, however. A report on later work done by the Conference was presented in a paper, "Fluid-Meter Research at the University of Oklahoma," by W. H. Carson and E. E. Ambrosius at the Annual Meeting of the A.P.I., Chicago, November 14, 1940.

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Electrical Protection and Use of Light-Weight Pipe in Pipe-Line Construction

☆ **Protection of pipe against external and internal corrosion by modern available methods can lead to great economies in the use of steel**

by Walter F. Rogers

Gulf Oil Corporation

Foreword

In view of the importance of pipe lines to the Nation's war effort, the articles in this Pipe Line Section have a special significance. The information they contain will be found to have concrete value in helping to point the way to speedier construction practices, how better to conserve vital materials, and how to improve maintenance and operating practices on our pipe-line systems.

ELECTRICAL drainage or cathodic protection, as it is more commonly called, has demonstrated its dependability as a method of preventing soil corrosion of buried pipe. A sizeable bibliography has been developed on the subject and there is considerable agreement, among those employing the method, both as to its reliability and as to the essential features required for a successful installation. Repairs made necessary by soil corrosion have long been one of the greatest items in the maintenance of oil and gas pipe lines. Now that there is available a method for eliminating entirely external corrosion of buried pipe, it is advisable to examine the factors involved in designing pipe lines to determine the full value of the use of electrical protection. Only by so doing can the pipe-line engineer be satisfied that full advantage is being taken of its possibilities. This development of the proper place of electrical protection in pipe-line design requires a determination of the economies of the system for bare pipes and coated pipes, and its usefulness in allowing the reduction of pipe wall thickness to the minimum required for the pressure to be handled.

Pipe Wall Requirements

The greatest item of expense in the construction of a pipe-line system is the cost of the pipe. It is important, therefore, that the correct pipe size and weight be selected, because every pound of steel purchased unnecessarily is both poor engineering and an economic waste. There is some evidence that full advantage has not been taken by the pipe-line industry of both the art of making steel pipe and the art of protecting it.

The first pipe lines laid in the Mid-Continent area during the early 1900's were made of wrought iron and low carbon steel. These pipes were formed by the lap-weld process and the joints were screw-coupled. These metals have yield point values of 20,000 to 25,000 lb. per sq. in. and ultimate strength values of 40,000 lb. per sq. in. Pipe lines at that time were constructed of 6-, 8-, and 10-in. pipe with the first two sizes predominating. Pumping pressures varied, but ranged from 500 to 750 lb. per sq. in. Using the common formula, the pipe wall thickness required at 750 lb. per sq. in. pumping pressure, using 25,000 lb. per sq. in. yield point metal, is:

$$T = \frac{PD}{2S}$$

Where:
T = wall thickness, in.,
P = pressure, lb. per sq. in.,
D = inside pipe diameter, in., and
S = fiber strength, lb. per sq. in.

Pipe diameter, in.	*Wall thickness, in.*	*Wall thickness (factor of safety on yield point = 2)*
6	0.090	0.180
8	0.120	0.240
10	0.150	0.300

After taking the thread depth for the screw-coupled pipe of 0.100 in. and the efficiency of the lap weld into consideration, the final weights of pipe adopted for screw-coupled line-pipe service were:

Pipe line, in.	*Wall thickness, in.*	*Weight, lb. per ft. (threads and couplings)*
6	0.280	19.45
8	0.322	29.35
10	0.365	41.85

Comparison of these two tables shows the wall thickness adopted for standard pipe to be greater than that calculated for a factor of safety of 2 by 0.100 to 0.065 in. or about the thread depth.

These weights of pipe have remained the standard for line pipe. Improvements in the art of making steel, however, have resulted in the development of stronger steels and improved methods of pipe manufacture. A.P.I. Grade B line pipe has a minimum yield of 40,000 lb. per sq. in. and an ultimate yield of 60,000 lb. per sq. in. In addition, line pipe may be made either by the seamless or electric-weld process,

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either method insuring a pipe wall of even strength, which was not the case for the early fire-weld pipe.

In addition, present-day pipe is connected in the field by welding rather than by screw coupling. These welded joints are as strong, or stronger, in the pipe joint as in the body and there is no loss of wall section as required by threads.

As a result of these advances the old standard weights of line pipe are no longer necessary for pump pressures of 750 lb. per sq. in. Using the same factor of safety as before, i.e., 3 on the ultimate strength or 2 on the yield point, Table 1 has been prepared to show the weights of pipe required for 750 lb. per sq. in. pressure. The pipe is A.P.I. Grade B line pipe of seamless or equal construction and is to be coupled by welding. As earlier lines were seldom larger than 12 in., the table shows for comparison the old standard weights of pipe through this size.

In addition, the money saved per mile by the use of the light-weight pipe is listed.

These data show some startling possible economies. The use of the light-weight pipe permits savings varying from $2060 per mile for 6-in. pipe to $5010 per mile for 10-in. pipe. This is, of course, entirely the result of reducing the pipe wall thickness to 0.169 in. for 6-in. pipe, 0.180 in. for 8-in. pipe, and 0.203 in. for 10-in. pipe.

The normal thicknesses for standard weight 6-, 8-, and 10-in. pipes varied from 0.280 to 0.365 in. Reference to the table shows that the 0.365-in. wall for standard 10-in. pipe is only exceeded by light-weight pipe of 20-in. diameter and greater. The table further shows that only 18-in. diameter light-weight pipe and larger exceeds the 0.322-in. wall thickness of 8-in. standard pipe, and only 16-in. and larger light-weight pipe exceeds the standard 6-in. diameter pipe wall thickness of 0.280 in. Thus, all pipe under 16-in. diameter can have a wall thinner than that used previously for 6-in. pipe.

As regards the pipe strength, these wall thicknesses can be relied upon to stand the pressures for which they are designed. Now the question that arises is the safety of the pipe from corrosion attack. If it can be shown that no metal wall need be added to prevent corrosion attack then there is no reason why the economic advantage of light-wall pipe should not be utilized.

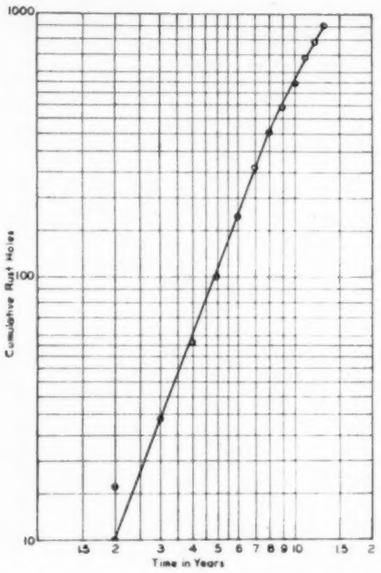


Fig. 1. Cumulative rust hole-time curve (470 miles of 6-in. pipe; wall, 0.280 in.)

Formula: $R = eT^f$

Where:

R = cumulative rust holes,

T = time in years,

e = R when $T = 1$, and

f = slope of curve.

TABLE 1

Comparison of light-weight and standard-weight line pipe

Pipe size, in.	Wall thickness of grade B line pipe for 750 lb. per sq. in. pressure (factor of safety on yield point = 2), in.	Pipe weight, lb. per ft.	Standard pipe		Weight difference, lb. per ft.	Price difference at $0.05 per lb. ($ per mile)
			weight, lb. per ft.	wall thickness, in.		
6	0.169	11.65	19.45	0.280	7.80	2060
8	0.180	16.23	29.35	0.322	13.12	3460
10	0.203	22.87	41.85	0.365	18.98	5010
12	0.250	33.38	51.15	0.375	17.77	4700
14	0.276	40.45	.....	.....	.....	....
16	0.302	50.63	.....	.....	.....	....
18	0.344	64.82	.....	.....	.....	....
20	0.375	78.60	.....	.....	.....	....
22	0.406	93.69	.....	.....	.....	....
24	0.437	110.10	.....	.....	.....	....

Wall Thicknesses

Corrosion attack of steel pipe must be considered from the standpoint both of the internal and external pipe environments.

A. Internal corrosion. Internal corrosion may or may not be a factor to be considered. The principal commodities handled by pipe line are crude oil, refined gasoline, and gas and practical experience has shown what is to be expected from each commodity.

Crude oils must be separated into two classes: sweet and sour (hydrogen sulphide bearing). Sweet oils have been handled through pipe lines since the first pipe line was laid. Sections of pipe have been cut from sweet oil lines in service for 20 years and no signs of internal corrosion found. As this has been found to be universally true, it can be said with certainty that no added metal wall or other internal protective step need be taken for lines transporting sweet oils.

Sour or hydrogen sulphide bearing crude oils will cause internal corrosion if they are not properly handled. The cause of corrosion by sour oils is the precipitation of water on the bottom interior of the pipe. Such accumulated pools of water contain hydrogen sulphide and this chemical has an acid pH.

In addition, the oil may supply oxygen to the water. Such a set of conditions will result in rapid corrosion attack. It has been found on tests conducted with full scale pipe that pit depths of 0.090 in. per year may be developed. Protection against such a pitting rate would require a pipe wall of 0.900 in. for a pipe life of 10 years. It has been found by test and confirmed by experience that these corrosive settlings can be prevented from accumulating either by pumping at high velocities or using a swab scraper periodically to keep the line clean. For lines under pressure the proper use of a swab scraper has been found to prevent this type of internal corrosion. The swab scraper obviously can only be depended upon when the line is free of moisture traps that the scraper cannot clean. This means that the welded ends must be free of inner rings, wrinkled recesses, etc.

When such obstacles are present and prevent cleaning by the scraper rapid corrosion will occur in the areas that cannot be cleaned. Knowing these conditions a new line can be laid to handle sulphide-bearing oils without the addition of metal for internal corrosion protection. The prevention of corrosion must be accomplished by other and known methods.

Refined gasoline lines also experience internal corrosion. A symposium on this subject held by the American Petroleum Institute at its twenty-second annual meeting divulged considerable information. Several broad principles have been established concerning this type of corrosion, as follows:

1. Every gasoline line has been

found subject to this form of attack. Thus, it is a universal form of trouble and not isolated to gasolines produced or handled only under specific conditions different from the industry in general.

2. Corrosion attacks around the entire pipe circumference and is not restricted to the pipe bottom.

3. The corrosion attack does not form deep pits ending in pipe-wall penetration but forms numerous shallow pits with the corrosion product forming tubercules on the pipe wall. These tubercles increase the friction factor of the pipe and reduce the line capacity.

4. The rate of pipe corrosion varies from 0.10 percent to 2.0 percent a year. This means that if the average loss is 2 percent a year a 25-year life can be expected before the pipe wall is reduced to a factor of safety of 1 based on the yield point.

Use of the swab scraper will prevent the formation of these tubercles. It will maintain the line capacity at its designed figure, but by constantly keeping the pipe clean the corrosion rate will remain high. There are inhibitors for preventing this corrosion and other methods are under study for its control or elimination. Because of the generally slow rate of corrosion and the certainly of technologic advancement in combating it no pipe wall should be added for this type of corrosion attack.

Gases also may be divided into sweet and sour classifications. Transportation of sour gas through long lines is not common practice and, therefore, does not present a great problem. When such gases are handled, they must be kept above the dew point or they will give rise to serious corrosion. No further consideration is given at this time, however, to the handling of this type gas because the amount of pipe in this particular service is relatively small.

Sweet gases are transported through long pipe lines. Like sweet oils, however, they do not give rise to internal corrosion so no metal wall need be added.

In general, therefore, it can be said that any internal corrosion that occurs to lines transporting crude oils, refined products, or gases may be satisfactorily handled by means other than added pipe wall, and only the weight of pipe needed to operate at the pressure to be used should be laid.

B. External corrosion. Soil corrosion of any extensive pipe-line system eventually results in areas of pipe-wall penetration. The laws governing this soil corrosion have been well established in general and are sufficiently well known to permit, from the proper data, calculations of the pitting rate to be obtained at future times in any soil or set of soils, as well as the calculations of the time of rust-hole penetration of different wall pipes for any given soil. Such calculations are not necessarily essential in this survey as no soil penetration will occur to the pipe if it is properly protected cathodically.

It is not practicable, however, to use light-weight pipe and not protect the exterior. This is shown by a calculation of the type referred to above for several hundred miles of 6-in. pipe having a wall thickness of 0.280 in. in an average group of Mid-Continent soils. Fig. 1 shows the rust hole experience of this pipe. These data are plotted on log-log paper and form a line having two different slopes. The curve follows the general type $R = eT^f$.

Where:

R = cumulative rust holes,

T = time in years,

e = R when T = 1, and

f = slope of curve.

The cumulative rust holes for this pipe at different wall thicknesses can be calculated from this formula or several similar to it. Making these calculations, Table 2 gives the number of rust holes for pipes of thinner wall for a period of 7 years. The table likewise shows the cost of repairing the same pipe at $80.00 per rust hole.

It will be noted that decreasing the pipe wall thickness from 0.280 to 0.180 in. results in repair costs increasing from $20,800 to $90,300. This would soon offset the money saved by using the lighter-wall pipe. Similar calculations for other size pipes show that the use of light-weight pipe should not be resorted to without protecting it. As a considerable saving is accomplished by the use of light-wall pipe there is no reason why a part of this money should not be spent to keep it externally safe from soil corrosion.

TABLE 2

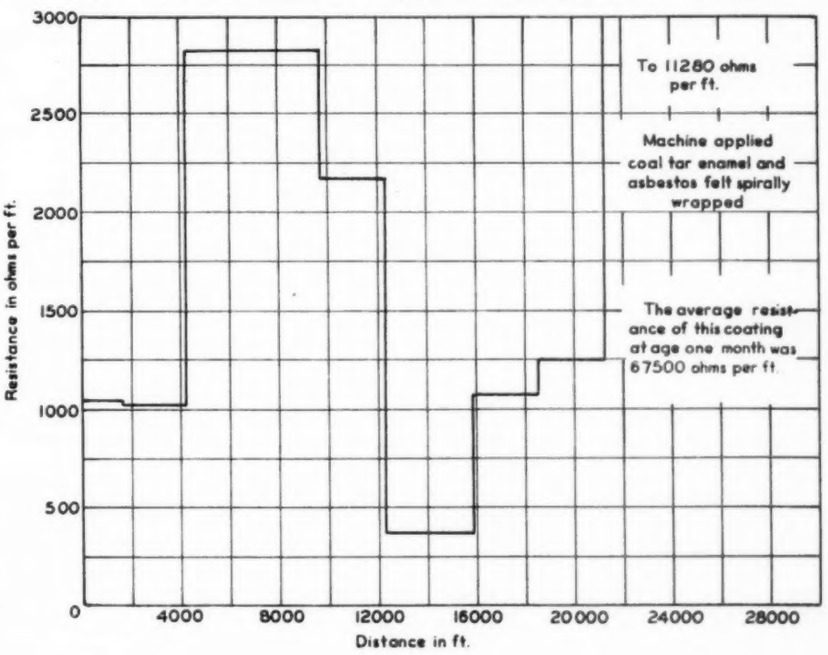
Pipe wall, in.	Cumulative rust holes at 7 years	Repair costs in 7 years at $80 per rust hole
0.280	260	$ 20,800
0.220	575	46,000
0.180	1130	90,300

Electrical Protection of Bare Pipe

Both bare and coated pipe may be protected electrically with equal success. The cost of using cathodic protection on bare pipe is much greater than for coated pipe, with regard both to installation and power costs.

In protecting bare pipe, experience has shown that an average of 4 to 6 ma. per sq. ft. of pipe surface should be used. This is equivalent to approximately 50 to 75 amp. per mile of 8-in. pipe. It is further necessary to flow the current onto the pipe so that every square foot receives close to its required average amount. The amount of current picked-up by a bare pipe from a

Fig. 2. Electrical resistance of a pipe-line coating after 14.2 months



single anode can be calculated from the equation:

$$I = Io e^{-\alpha x}$$

Where:

I = the current in the line at any place,

Io = the current in the line at the drain,

e = base of normal logarithm,

x = the distance from the drain, in ft., and

$$\alpha = \sqrt{\frac{A}{K}},$$

Where:

A = pipe resistance in ohms per ft., and

K = soil or coating resistance in ohm-ft.

The average Mid-Continent soil will have a resistance of 1500 ohm-cm. at saturation or 50 ohm-ft. If a 25-amp. current source is installed the average value of 4.1 ma. per sq. ft. will be obtained 1000 ft. from the drain if there is another unit 1000 ft. away. Thus, 25-amp. units can be installed about 2000 ft. apart for a single bare 8-in. line. This does not mean that 50-amp. units can be installed 4000 ft. apart and have a minimum current density of 4.1 ma. per sq. ft. In this case the minimum becomes 2.6 ma. per sq. ft., which is less than the protection value. Good design calls for approximately the spacing above of 25-amp. units at 2000 ft. intervals. If the soil resistance becomes much less than 50 ohm-ft. the spacing will have to be closer.

The cost of protecting bare 8-in. pipe can be calculated:

$$\text{Amperes per mile} = 25 \times \frac{5280}{2000} = 66$$

Voltage = Approx. 8.0

Power per year per mile at 60 percent efficiency for transmission and rectification at 1½ cents per kw-hr. =

$$\frac{66 \times 8 \times 8.640 \times 0.015}{0.60} = \$116.00$$

The use of such closely spaced power installations calls for a high-tension transmission line. The total investment required is largely influenced by the type of transmission line installed. If a standard 3-phase construction is used the power line will cost about $1000 per mile. If R.E.A. type single-phase line is used this figure will be reduced to about $500 per mile. The installation costs per mile will be:

Rectifier capacity at $4.00 per amp.	$ 264.00
Ground beds and installation (400 ft. total of 6-in. pipe)	400.00
Pole line	1000.00
Total cost	$1664.00

If the R.E.A. type line is used this cost will be reduced to $1164.00 per mile.

The total cost per year per mile will be:

Power	$ 116.00
Depreciation (5 percent on pole line, 20 percent on ground bed, and 10 percent on rectifier)	156.00
Interest on investment	83.00
Total cost	$ 355.00

The cost is $355.00 per mile year for standard pole line construction and $305.00 per mile year for R.E.A. line construction.

It is doubtful whether such an installation is warranted on bare pipe. The governing factor will be the rate of leak formation and the cost per leak. When these factors are known it is easy to calculate the economies of installing electrical protection.

Protecting Coated Pipe

When light-wall pipe is to be laid it is well to figure the economies of laying the pipe coated and employing electrical protection to take care of any areas where penetration of the coating may occur. A coating commonly used to obtain reasonably good electrical resistance is one coat of hot enamel followed by a spirally applied asbestos wrapper. The cost of such a coating applied to new 8-in. pipe is $1000 to $1100 per mile.

When such a coating is used the current necessary for complete protection is only a fraction of that required for bare pipe. The criterion for correct protection in the case of well-coated pipe is not amp. per sq. ft. but a minimum pipe-to-soil potential. This minimum potential for complete protection when measured to a copper sulphate electrode is 0.86 to 0.90 volt. The current necessary to attain this potential is entirely dependent upon the coating resistance. If this resistance is known the current required is readily calculated. The initial current for this potential will gradually increase as even good machine-applied coating experiences lowered resistance values with time. This is due to water absorption, soil stress, clod indentations, etc. Thus the size of a power unit installed on a new line must be adaptable to somewhat increased power demands with time. Fig. 2 shows the change in resistance of a machine-coated pipe in 14.2 months. The pipe was laid in a Texas Gulf Coast soil containing a relatively high percentage of clay. The coating was 0.090 in. of coal tar enamel and a bonded spirally applied 0.023-in. asbestos felt wrapper. The initial resistance averaged 67,500 ohms per linear ft. This is an extremely high coating resistance and complete protection was obtained on 25 miles of pipe with about 11 amp. dissipated from a single station. After 14.2 months the coating resistance has fallen to values ranging from 375 to 11,280 ohms per ft. It is not likely that much additional loss of resistance will occur as it has been found from experience with other coatings that they have changed but little after two years of aging underground.

Protection for the line is now obtained with a total of about 30 amp. The cost of electrical protection for this 25 miles of pipe is about $1000 for installation cost and a $150.00 per year cost for power, depreciation, maintenance, etc. This is $6.00 per pipe-line mile per year, which is within the precision of estimating the coating cost at $1000 to $1100 per mile. Allowing 5 percent depreciation value on the coating, 5 percent for interest, and $6.00 per year for cathodic protection, the total cost for protecting this pipe with a coating and electrical protection is $116.00 per mile year. This is from $199.00 to $239.00 cheaper per mile year than if the pipe had been laid bare and protected only by electrical drainage.

Similar calculations for other sized pipes show that the most economical method of protecting light-weight pipe from soil corrosion is to coat it when laid and superimpose electrical protection.

Summary and Conclusions

Data have been presented to show that pipe lines should be laid of pipe of the lightest weight steel needed to withstand the pressure of pumping. The pipe should be welded without inner chill rings, recesses, etc. Such construction should be used for sweet and sour crude oils, refined products, and sweet gases.

Any internal corrosion that might tend to occur can be prevented by known methods and no additional metal wall should be added for corrosion protection.

External protection against soil corrosion should be obtained through the use of a joint coating-electrical protection program. Such a method of laying pipe will result in the saving of several thousand dollars per mile of pipe, the exact expenditure depending upon the pipe size.

Acknowledgment

The writer wishes to thank the Executive Department of the Gulf Oil Corporation for its kind permission to publish this article.

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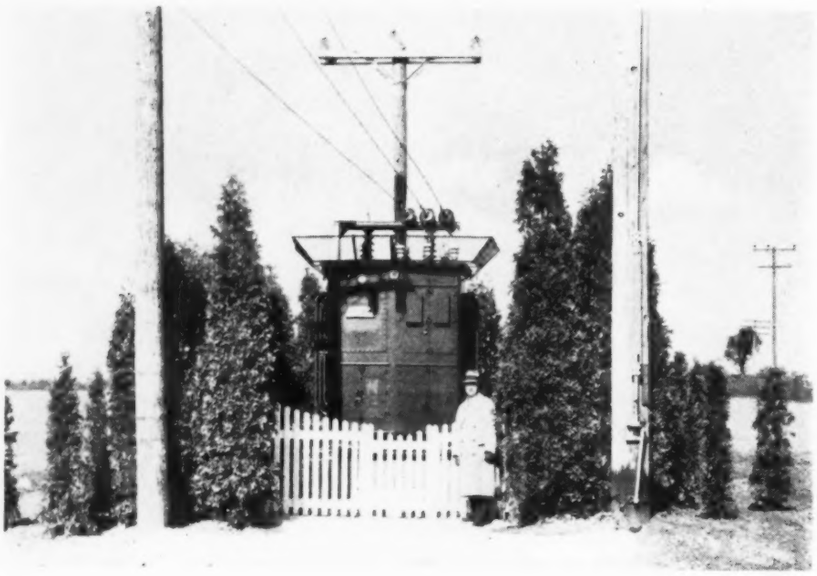


Fig. 1. Installation of a complete unit-type substation with CSP power transformers, showing the incoming high-voltage line and outgoing low-voltage line

A PETROLEUM ENGINEER Exclusive Feature

"Blueprint" for Conserving Time

by H. E. Dralle

Manager, Petroleum and Chemical Engineering Section, Westinghouse Electric and Manufacturing Company

THE transfer of a number of tankers to the Pacific and further depletion of the tanker fleet by losses in the Atlantic again bring into prominence the pipe line as a likely possibility, if not a necessity, for transporting crude oil from the south and midwest to the eastern seaboard. When such a line or similar ones become realities, adoption of a number of advanced engineering ideas in the application of electricity to this service will result in improved performance as well as savings in time and materials so vital in connection with the all-important program of effectively prosecuting the war.

Before considering details of operations resulting from use of equipment in keeping with these new ideas, it is well to point out that their adoption does not introduce the objection or possible hazard often incident to new and untried systems. Especially is this true as there is involved no newly developed equipment but rather only functional arrangements and modified ratings of electrical apparatus fully proved in countless other applications.

Let us consider the sound, practical engineering applications embodied in these proposed new ideas and briefly compare them with accepted standards for electrically driven pipe-line stations. To facilitate discussion, these following specific items will be considered in order:

1. Substations. (Outdoor type complete with self-protected transformers, switching and protective devices, including tap-changing-under-load equipment for providing reduced starting voltage on the motors.)

2. Motors. (60°C. open squirrel-cage and 75°C. totally-enclosed, fan-cooled, explosion-resisting.)

3. Switchgear. (Metal clad type including breakers, busses, metering, and station control.)

H. E. DRALLE

graduated as an electrical engineer from the University of Illinois in 1916, and since then has been associated continuously with Westinghouse—After general engineering activities, Dralle specialized in the application of electricity to the cement, glass, railroad, and oil industries—In the fall of 1922 he began specializing in oil industry work—As a specialist in the application of electrical machinery to the many phases of the oil industry, he was sent on a trip to the most important oil fields of Europe and the East—This 17 months' trip extended over 37,000 miles and into 26 different countries—Prior to his appointment as manager of the petroleum and chemical engineering section he was gearing representative in the northwestern and southwestern districts for Westinghouse's Nuttall Works.

Substations

To step down, at each pumping station, any available high-tension voltage to that used at the motor terminals, usually 2300 volts, 3 phase, 60 cycles, the use of an outdoor unit-type substation offers direct advantages in operating performance and savings in time and essential materials. This unit substation, illustrated by Fig. 1, embodies a 3-phase, oil-insulated, self-cooled, completely self-protected main power transformer, and a 3-phase auxiliary power transformer, together with all switching and protective devices enclosed in a single, self-contained, weather-proof case. Such a unit is readily put into service. It requires only a simple foundation and easily made electrical connections to the high- and low-tension terminals.

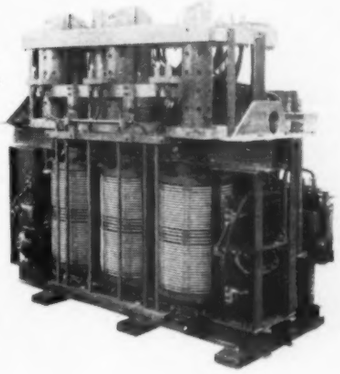
Fig. 2 is exposed assembly views of important parts of the unit substation. In the upper compartment is shown the de-ion, air circuit breaker on the low-voltage side of the transformer. Fig. 3 shows a typical core and coil assembly of CSP transformer viewed from the high-voltage side.

The installation time for a station of this type requires less than one-fourth the man hours required for a conventional type substation made up of single-phase transformers, and individually housed and supported switching, control, and protective devices. This immediately effects savings in construction expense as over-head steel supports, insulators, and nine-tenths of construction labor are eliminated at the site.

Obviously, elimination of the construction labor on site means added

Fig. 2. (Left)—Complete CSP substation unit with all doors open and panels swung out showing arrangement of the equipment

Fig. 3. (Right)—Core and coil assembly for a 13.2-kv. CSP unit-type transformer as viewed from the high voltage side



☆ **Recommendation for type of substations, motors, and switchgear to install at electrical stations**

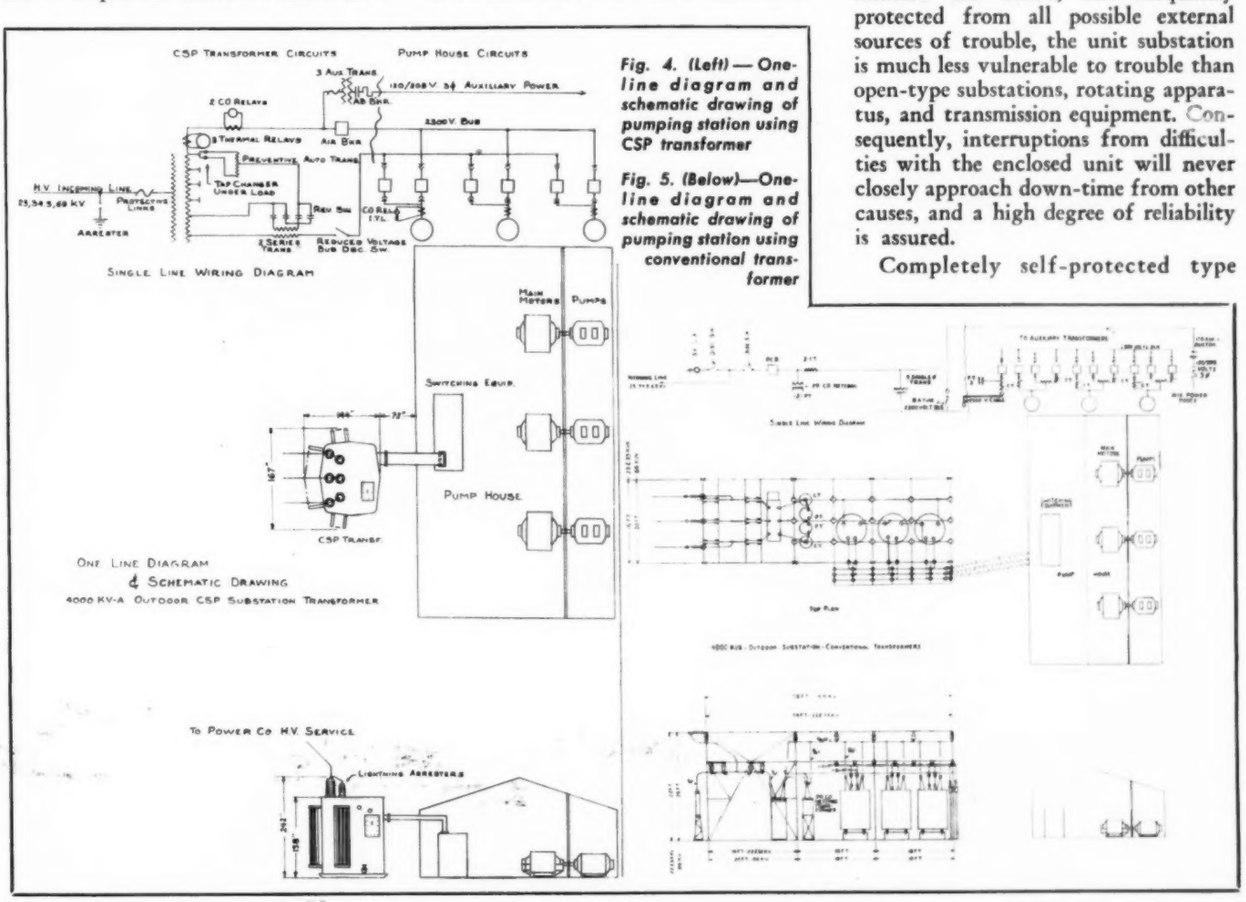
and Materials on Pipe-Line Systems

man hours at the factory to completely assemble the unit substation. But a factory assembled and tested unit permits complete coördination of all apparatus, protective and control devices, resulting in economical and efficient use of important materials and consequent lowered maintenance. Figs. 4 and 5 present a general comparison between the unit substation and the conventional type.

Besides the advantages already enumerated, a unit-type substation possesses such other desirable features as low degree of vulnerability, high measure of reliability, low-cost insurance against shut downs, possibilities for standardization, and time savings in purchasing and expediting equipment.

With all parts enclosed, factory assembled and tested, and adequately protected from all possible external sources of trouble, the unit substation is much less vulnerable to trouble than open-type substations, rotating apparatus, and transmission equipment. Consequently, interruptions from difficulties with the enclosed unit will never closely approach down-time from other causes, and a high degree of reliability is assured.

Completely self-protected type



Single Line Wiring Diagram

One Line Diagram & Schematic Drawing
4000 KV-A Outdoor CSP Substation Transformer

Fig. 4. (Left)—One-line diagram and schematic drawing of pumping station using CSP transformer

Fig. 5. (Below)—One-line diagram and schematic drawing of pumping station using conventional transformer

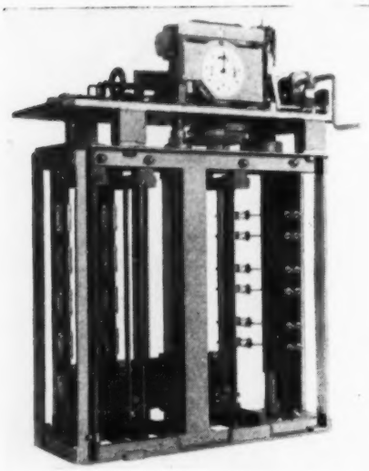


Fig. 6. The mechanism for tap-changing-under-load to obtain reduced voltage starting of the motors

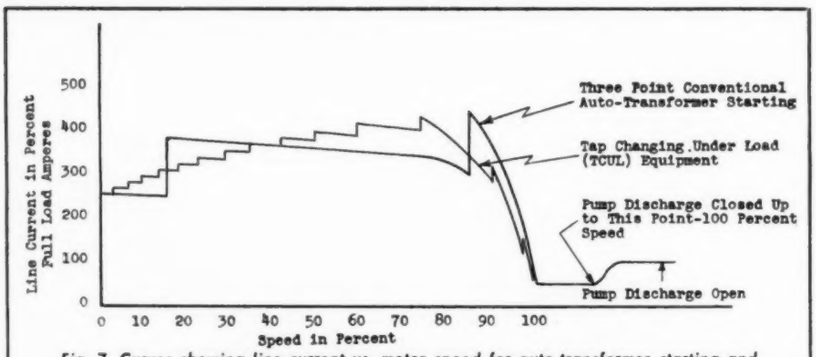


Fig. 7. Curves showing line current vs. motor speed for auto-transformer starting and tap-changing-under-load equipment on 2-pole motors

transformers — the heart of the unit substation—in service have established new yardsticks for measurement of reliability. Conservative estimates from prevailing records place the probable failures from all causes at less than one in a hundred years. In other words, for a pipe line requiring 25 stations the anticipated 3-phase transformer failures would not exceed one in every four to five years.

There is a definite trend in power work toward the use of 3-phase transformers instead of three single-phase transformers. At present, more than half the power transformers sold are 3-phase; whereas five or six years ago very few 3-phase units were in use. This change to 3-phase units has been brought about by the establishment of new reliability, economy, and performance standards afforded by these complete, self-protected, and enclosed units.

Such high degree of reliability provides low cost insurance against shut down. Only two complete units would be required as spares. They could be designed with primaries capable of working on any supply voltage along the line and could be mounted on trailers for moving to any location by truck or train. These units could be placed at the most strategic points for quick transportation to minimize down time on any station. Standardization possibilities for stations of this type are apparent. All stations regardless of primary voltages would be similar in construction and appearance. Their employment would permit single transactions with consequent time-savings in purchasing and expediting equipment as this single unit combines the functions of a great many devices.

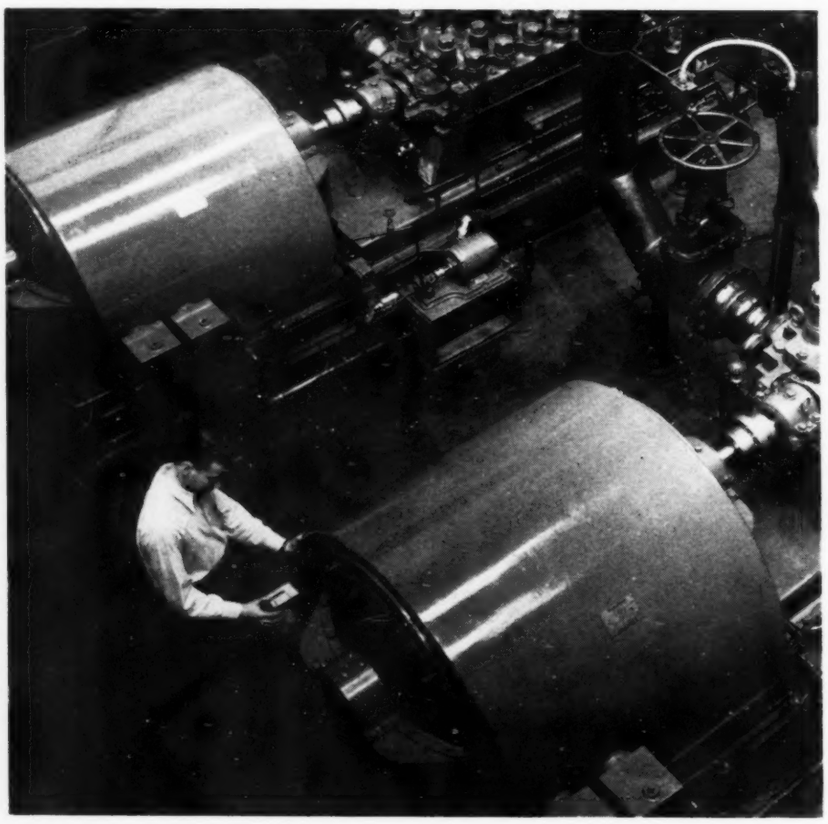
Perhaps the most unusual feature of this unit-type substation is the method employed for obtaining reduced voltage for starting the motors. This new method obviates the use of conventional type auto transformers for use in motor starting by utilizing tap-changing-under-load equipment on the main transformer to supply reduced voltage on a starting bus in the pump house.

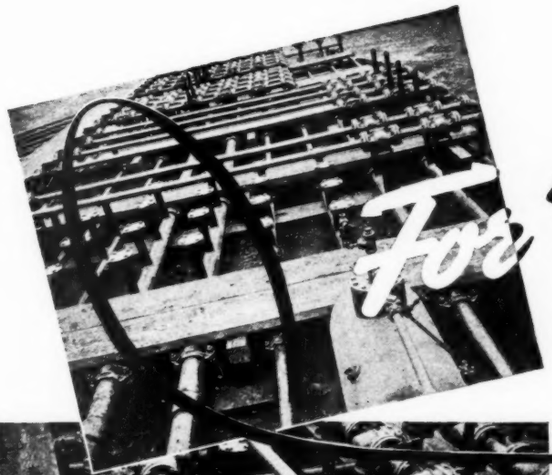
A close-up view of the tap-changing-under-load equipment is shown in Fig. 6.

The tap changer is motor-operated and set in motion by a push button at the desired pump in the pump house. When a "start" button is pressed, the tap-changing equipment automatically brings the voltage on the starting bus from 60 to 100 percent voltage in 16 steps (closed transition). As the full-voltage position is reached, an auxiliary switch on the tap-changer causes the running breaker to close, throwing the motor on full voltage on the running bus. The starting breaker then trips the tap changer and immediately returns to the position providing minimum voltage on the starting bus.

Usually more than one motor is to be started in a single station. It is noteworthy that any number of motors may be safely started in quick succession. All starters are interlocked so

Fig. 8. Two 1250-hp. open, drip-proof motors driving centrifugal pumps





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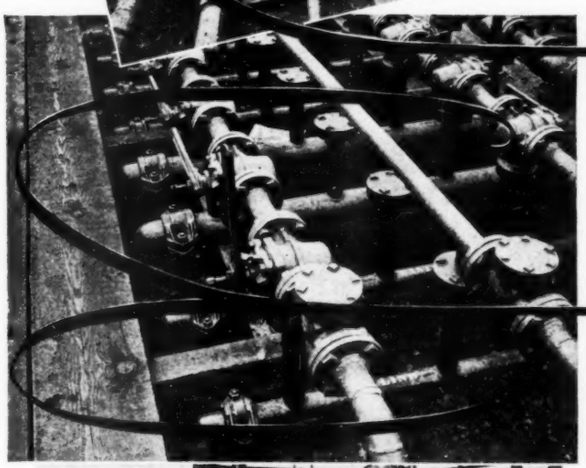

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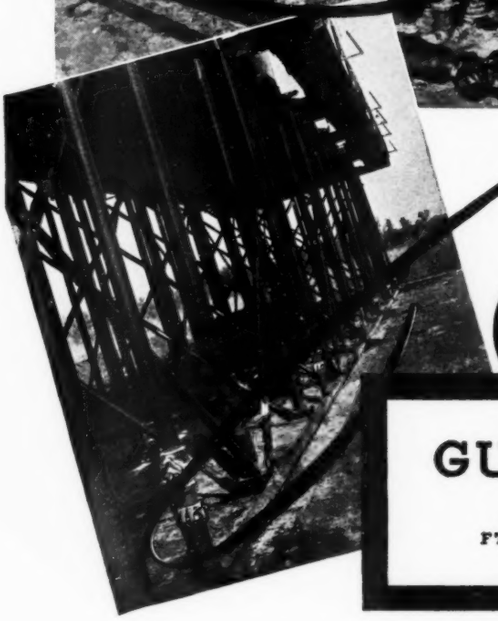

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that only one motor is on the starting bus at one time.

This new scheme immediately eliminates much material normally required for the auto transformers, busses, and switches in the pump house and simplifies that which of necessity remains. Besides this, greatly improved starting conditions, both from the standpoint of current peaks on the power line, as well as mechanical shock to equipment, are provided. This is more clearly depicted in Fig. 7, which shows the nature and relative values of line currents when using the new tap-changing-under-load method and the three point, closed transition conventional method of reduced voltage starting. Note the three pronounced current peaks at the 65, 80, and 100 percent voltage taps on the auto transformer and the much smaller current peaks with the tap-changing-under-load equipment as the voltage is gradually raised in 16 steps (closed transition) from 60 percent to full voltage. Needless to say the smaller peaks minimize shock to both the electrical and mechanical equipment.

Motors for Pipe-Line Service

Motors for pipe-line service may be of the open type as shown in Fig. 8 or of the totally enclosed, fan-cooled, explosion-resisting type in Fig. 9, the choice depending upon the nature of product carried by the line.

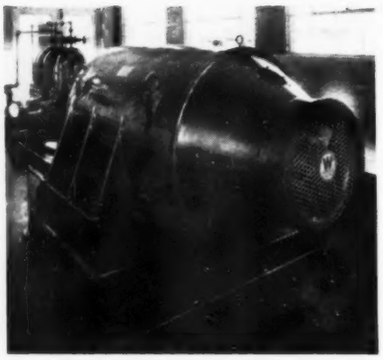

Fig. 9. A 2-pole explosion-resisting motor driving centrifugal pump

Open motors are rated on the basis of 40°C. rise and enclosed motors on the basis of 55°C. rise when employing Class A insulation. As is well known, Class "A" insulation is basically organic and therefore subject to deterioration at definite top temperature limits.

The use of Class B insulation, which is basically inorganic and therefore not materially affected by temperature within the range considered, 125°C. total temperature, permits rating open and enclosed motors at 60°C. and 75° C. rise, respectively.

By increasing the permissible temperature rise on motors with the Class B insulation more horsepower and at least equal serviceability of the motors are available for a given amount of active iron and copper. In the interest, then, of economizing on iron and copper and minimizing the size of frame for any horsepower rating, the high temperature ratings are a practical and logical choice.

Switchgear

With the unit-type substation as described, where all apparatus is out-of-doors and only low-voltage leads brought to the pump house from both the main and auxiliary transformers, the former at 2300 volts to supply the main motors, the latter at 120/208 volts to supply power for lighting and small motors in the station, the switchgear in the pump house is greatly reduced in both amount and cost. Fig. 10 shows the type of metal-clad switchgear panels that would be desirable for the pumping station. A station having three motor-driven pumps and requiring reduced voltage starting requires a 12-panel switchboard with the conventional method of operation and only nine with the proposed new method of using tap-changing-under-load equipment.

Fig. 10. Typical metal-clad switchgear used for motor control

Summary

To summarize, we have suggested, as appropriate to the times, that for any major pipe line additions consideration be given to the use of:

(1) Completely self-protected unit-type outdoor substations with tap-changing-under-load equipment for reduced voltage starting of the motors.

(2) 60°C. open or 75°C. totally closed motors with Class "B" insulation.

(3) Unitized metal-clad switchgear.

Such equipment is in line with sound and practical engineering and will result in:

(1) Saving of vital and important materials.

(2) Savings in purchasing, expediting, and installation time.

(3) Savings in equipment weight.

(4) Minimum maintenance and power losses.

(5) High degree of equipment standardization.

(6) Improved reliability from using completely coördinated, factory wired and assembled apparatus.

(7) Improved overall performance on equipment and power lines.

(8) Simplification of apparatus.

The direct advantages to be gained by the use of such equipment on major pipe-line applications would in normal times commend its study, but present war aims and requirements may well demand its adoption.

——☆☆☆——

Pipe Line
P 543.6
P 629.2

Eliminating Hydrate Formation in South Texas

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☆ High-pressure gases demand study and research on hydrate formation for successful operation of elimination equipment

by Frank H. Dotterweich

Professor of Natural Gas Engineering, Texas College of Arts and Industries

PRODUCTION of high-pressure natural gas in South Texas producing areas is being accompanied by many problems relating to hydrate formation. These high-pressure gases, when allowed to expand, decrease in temperature and unless precautions are taken in field and plant operation, serious operating trouble results. Considerable research on hydrate formation[1] and regulator freezing,[2] together with advanced work on temperature-entropy diagrams for wet gas[3] has enabled the engineer better to understand these freezing problems, and design and place into successful operation equipment to eliminate them.

The role of gas hydrates in natural gas systems was first reported by Hammerschmidt,[4] whose work has been substantially checked by a joint investigation of the U. S. Bureau of Mines and the American Gas Association under the supervision of W. M. Deaton and E. M. Frost. This work by the Bureau is now being continued and additional information is desirable due to increasing difficulties brought about by deeper drilling, increased pressures, and the retrograde effect of water and hydrocarbon systems.

In many of the high-pressure trunk lines it may be desirable to install dehumidification plants to prevent the formation of gas hydrates. The conditions existing in South Texas, however, dictate that the installation of such equipment is neither economical nor warranted in gathering lines, transmission systems, and cycling plant operation. In most cases hydrate formation is induced only at infrequent intervals with existing equipment, due to climatic conditions and then only for short intervals. In such cases where pressure and temperature induce hydrate formation, well-designed heaters and heat interchangers are being employed. One case, however, is noted in which dehydration is being effected in plant operation.

FRANK H. DOTTERWEICH

was graduated from the Baltimore Polytechnic Institute in June, 1923—Was employed by this institution as an instructor until June, 1925—Entered Johns Hopkins University in September, 1925, and received the degree of bachelor of engineering in gas engineering in June, 1928—Employed by the Consolidated Gas Electric Light and Power Company of Baltimore as a cadet engineer, general foreman, and assistant to general superintendent of gas operations—Re-entered Johns Hopkins University as a graduate student in October, 1934, and received degree of Ph.D. in June, 1937—At present is professor in natural gas engineering at the Texas College of Arts and Industries, Kingsville, Texas—Is a member of the chemical committee of the American Gas Association and is serving on the subcommittees, "New Developments," rewriting the "Gas Chemist's Handbook," and revising the "Fuel Flue Gas Handbook."

The work of Deaton and Frost[5,6] is of great help in the design and operation of such equipment. These investigators have experimentally determined gas hydrate decomposition curves for a number of natural gases and for several pure gases. A portion of their work is shown in Fig. 1. It will be noted that the hydrate curves of natural gases are found to lie within the curves for methane and ethane. In addition, they report the higher B.t.u. gases form hydrates more readily than those of lower B.t.u. content and that no simple relationship has been found that will enable one to predict the hydrate characteristics for the gas from its analysis.

In general, Deaton and Frost have shown that the curves for natural gas when plotted on semi-log cross-section paper are straight parallel lines and may be represented by the equation:

$$T = a + 33.5 \log P.$$

Where:

T = temperature, °F., and

P = pressure, lb. per sq. in., abs.

The constant (a) varies with the type of gas being investigated and may vary from —42.8 for a dry gas to —32.1 for a gas with a greater percentage of the heavier hydrocarbons. At pressures, generally in excess of 1000 lb., breaks in the curves are noted and this suggests that additional experimental work at higher pressures is necessary. When the gas analysis is known reference to this work makes possible the calculation of the hydrate temperature and with this information available design work may progress with a greater degree of certainty. In addition Deaton and Frost have published many useful tables from which hydrate formation temperatures may be obtained for various types of gases.

Hydrates in Cycling Plants

In South Texas many hydrate problems are encountered in the various processes by which condensate is extracted. In the removal of condensate, three general methods are being used: first, high-pressure oil absorption; second, those using extreme cooling and separation with or without dehydration, and third, those using moderate cooling and separation.

[1] "Constitution Diagrams and Composition of Methane and Ethane Hydrates," by O. L. Roberts, E. R. Brownscombe, and L. S. Howe. *Proc. American Recycling Association*, 1940, pp. 71-90.
"Phase Diagrams of Methane and Ethane Hydrates," by O. L. Roberts, E. R. Brownscombe, L. S. Howe, and H. Ramser. *The Petroleum Engineer*, March, 1941, p. 56.

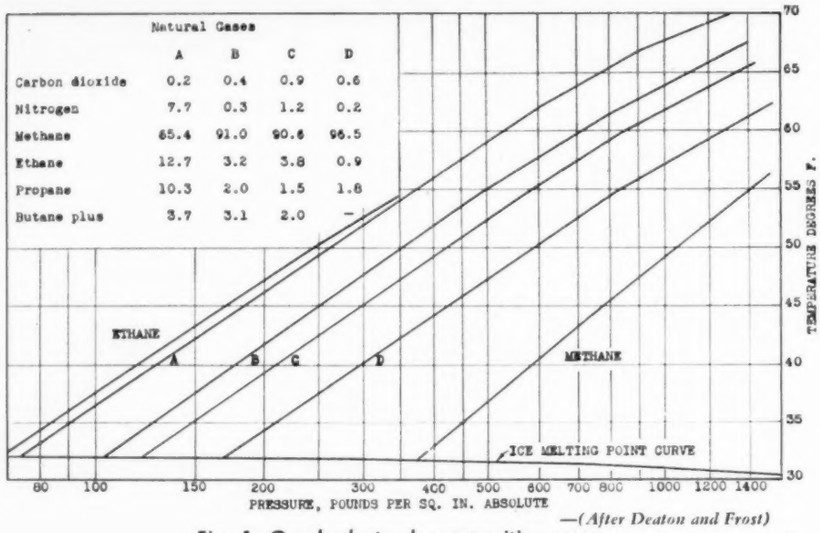
[2] "The Freezing of Natural Gas Regulators," by W. C. Mitchell, S. Cromer, and R. L. Huntington. *Gas Age*, January 4, 1940, pp. 17-21.

[3] "The Thermal Properties of a Wet Gas," by G. G. Brown and F. Kurata. *The Petroleum Engineer*, December, 1941, pp. 21-28.

[4] "Gas Hydrates," by E. G. Hammerschmidt. *American Gas Association Monthly*, Vol. 18, No. 7, 1936, pp. 273-276.

[5] "Gas Hydrates," by W. M. Deaton and E. M. Frost. *Natural Gas Section, American Gas Association Proceedings*, 1938, pp. 112-119.

[6] "Hydrates of Natural Gas, Pure Gases and Synthetic Gas Mixtures," by W. M. Deaton and E. M. Frost. *Natural Gas Section, American Gas Association Proceedings*, 1940, pp. 122-128.



—(After Deaton and Frost)

Fig. 1. Gas hydrate decomposition curve

In the high-pressure oil absorption process, operating temperatures are greater than those at which hydrates may be expected, and hydrate trouble, in general, is encountered only during very cool weather when regulation units are exposed. This condition may be offset by plant control without serious effect upon efficiency of removal, in that at the extremely high absorption pressures used in modern-day practice, temperature does not influence solubility constants to the same degree as was experienced in low-pressure operations. Plant control together with manual controlled heating units is sufficient to offset hydrate problems in high-pressure oil absorption procedures during certain periods of the year.

The method of extracting condensate by extreme cooling, with or without dehydration, may be further classified into high- and low-pressure systems. An example of a high-pressure system was the Chicago Corporation's plant in Stratton field before its conversion to that of high-pressure oil absorption. Before the changeover, gas was received at the plant at about 2000 lb. and at a temperature of about 120°F. Cooling towers lowered the temperature to about 70°F. and after water removal by drips a calcium chloride solution was added. This brine solution lowered the temperature of hydrate formation and by adiabatic expansion and well-designed heat interchangers a temperature of 20°F. at 1200 lb. pressure was obtained. This condition insured satisfactory condensate removal in the absence of hydrate formation. The brine solution was then extracted from the condensate, reconditioned, and recycled. An example of a low-pressure system of extreme cooling and separation is the Duval Gasoline Company's plant at Benevides. In this plant gas enters at atmospheric pressure and is compressed to 60 lb., then dehydrated by an adsorption process using activated aluminum as the adsorbing medium. With propane as the refrigerant and with efficiently operated and designed heat interchanges the gas is cooled to —40°F. at which temperature final and complete removal of condensate is obtained. Dehydration in this operation is the answer to hydrate problems.

When condensate is extracted by moderate cooling and separation, various problems are encountered, in that low temperatures are required to give satisfactory yields. A plant of this type is the Southern Minerals Plant of Corpus Christi in the section that employs low-pressure oil absorption methods. The hydrate problems encountered here are somewhat related to those encountered in processing high-pressure gas for domestic and industrial distribution and such problems will now be discussed.

Hydrates in Production Systems

When high-pressure wet natural gas is conditioned for distribution to domestic and industrial customers, many problems relating to gas hydrates are encountered. Natural gas production systems may consist of two or more producing wells. These systems give varying gas temperatures, dependent upon output, when pressure reduction is being accomplished. These problems become more complex when production is from two or more sands, and increases the problem of predicting hydrate formation temperatures with varying chemical composition and condensate content of the gas. The simple addition of heat is not the satisfactory solution to this problem, but the application of carefully controlled heating systems is desirable that allow for the satisfactory removal of condensate and water, yet eliminate hydrate trouble.

Sufficient heat may be applied in the field to eliminate hydrate trouble, but unsatisfactory condensate and water removal will encourage hydrate trouble in transmission operations and in exposed regulation equipment in the distribution network.

A complex problem of this type has been encountered and solved by engineers of the Houston Natural Gas Corporation in their production system at Driscoll, Texas. This system, designed by R. M. Hutchison, is now in successful operation and the initial installations have been reported.[7,8] Increasing outputs and varying field conditions have necessitated additions to and changes in field operations that are reported as follows by reference to Fig. 2.

Wells No. 1 and 2 with wellhead pressures of approximately 1000 lb. and 1500 lb. and gas temperatures of 87°F. and 94°F., respectively, are connected to the conditioning train at (C) Fig. 2. These wells produce gas saturated with water vapor and varying amounts of condensate. Liquid entrainment is removed at (D) and the pressure reduced at (F) to about 800 lb. After the second separation the pressure is reduced at (I) to about 380 lb. The gas at this pressure is then delivered to the meter house for measurement, odorization, and further pressure reduction prior to entering the transmission line.

Considerable experimental work indicated that insulation of the entire conditioning train was necessary to eliminate varying temperatures from changing atmospheric conditions and that the necessary amount of heat could be applied and controlled by a heater installed at (E). This heater consisted of 80 ft. of 1½-in. pipe connected with return bends and enclosed in a jacket of 12-in. pipe 9 ft. 6 in. long. Heating water is circulated to the jacket by convection and a thermostat in the line cuts out circulation when the temperature is in excess of 120°F. The water is heated by a booster type water heater thermostatically controlled. Gas heated to about 115°F. when expanded to 380 lb. with high load conditions was found to be at a temperature of 60°F., at which temperature no hydrate trouble is experienced.

When production is obtained from wells No. 4 and 13 new problems are encountered. With pressures of about 1400 lb. and a gas temperature of

[7] "Hydrate Control in High-Pressure Condensate Lines," by R. M. Hutchison. *The Petroleum Engineer*, March, 1940, p. 146.

[8] "Have You Tried Overcoats on Your Regulators?", by R. M. Hutchison. *Gas*, October, 1939.

70°F., these wells make appreciable amounts of condensate. Additional heating apparatus is required in this case in that on expansion to 980 lb. for condensate separation, temperatures lower than 70°F. suggest hydrate trouble. To offset this condition a heater was installed at (A), provided with an overflow and storage tank for the circulating system. This heater, designed on the same principle as the heater in the conditioning train, heats the gas to about 90°F. This temperature allows for satisfactory condensate removal, but maintains a temperature in the separation reduction equipment in excess of the temperature for hydrate formation. This operation permits the gas to enter the conditioning train at (C) and at a temperature of about 60°F., at which temperature the heater at (F) experiences no difficulty in maintaining temperatures greater than those at which hydrates would form. Increased loads naturally will result in lower temperature brought about by constant heating surface and with this condition foreseen additional heating surface is available at (H). Gas enters the train at 980 lb. at (C) and the pressure reduction is made by the Fisher regulator in one step. The Grove regulators at (I) are set to pick-up the reduction should operating trouble develop.

Many tests have revealed that hydrate trouble will be encountered in this system with a pressure of about 360 lb. and a gas temperature of about 40°F. With a knowledge of the composition of the gas and substitution in the formulae previously reported a very good check in hydrate temperatures may be obtained. Curve on Fig. 1, is for a gas having practically the same analysis as the average gas produced for this system. It will be noted from this curve that hydrate trouble could be expected at 42.5°F. This is a very good check for this work as reported by Deaton and Frost against actual operating conditions.

Regulators and Hydrates

Another method to prevent hydrate formation, in field operations, is reported by Bruster[9] to be in successful operation in condensate fields near the Texas-Louisiana border. He points out that in the removal of condensate and water in a high-pressure separator the low temperatures necessary frequently cause formation of hydrates within the regulator resulting in unsatisfactory operation due to the formation of ice on the valve seat, causing chattering. This condition causes vibrations that increase the difficulties encountered in high-pressure gas measurement. To offset this problem he recommends that heating the gas ahead of the regulator be avoided and the regulator on the high-pressure separator be enclosed by a jacket of sheet iron, and water at a temperature just below the boiling point be applied to the regulator. It is reported that this allows for a high recovery of condensate and water and should hydrates be formed they will not adhere to the valve seat.

A review of the conditions under which hydrate trouble may be expected in South Texas, indicates that the necessary equipment and plant operation is in use to offset their formation. This in part may be attributed to valuable research work.

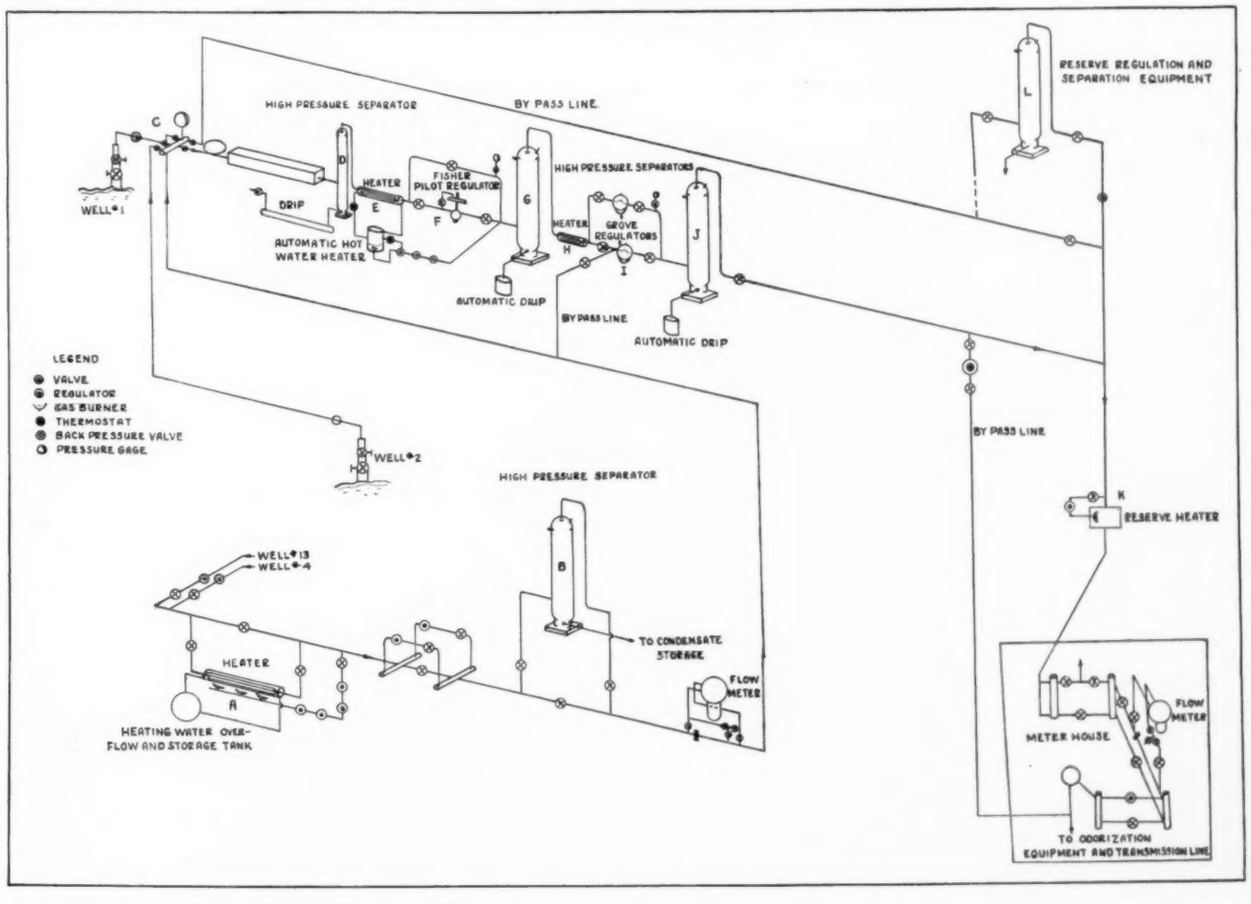
[9] "Preventing Hydrate Formation in High Pressure Regulators," by W. Bruster. *The Oil Weekly*, January 12, 1942, pp. 32.

Acknowledgments

The writer wishes to make acknowledgment to R. M. Hutchison, chief engineer, Frank Johnson of the Houston Natural Gas Corporation, and C. H. Gee of the La Gloria Corporation, for their help in supplying a part of the information contained in this article.

☆☆☆

Fig. 2. Driscoll production system of Houston Natural Gas Corporation



LEAVE IT TO ENGINEERS TO

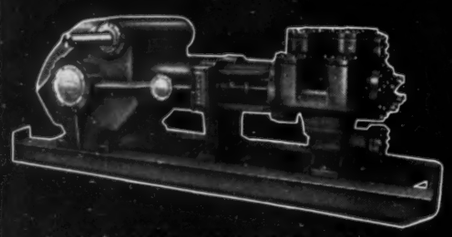


Fig. 2652. 12" stroke—176 bbls. at 1500 lbs. to 592 bbls. at 500 lbs.

Fig. 1741, with Diesel Drive—250 bbls. at 600 lbs. to 502 bbls. at 300 lbs.

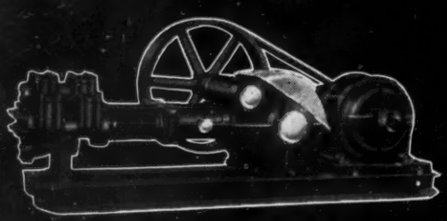


Fig. 1742. Electric Motor Drive. 54 bbls. at 1400 lbs. to 250 bbls. at 600 lbs.

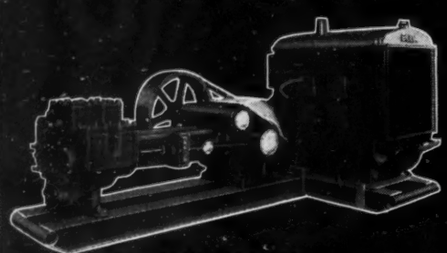


Fig. 1743. 156 bbls. at 925 lbs. to 578 bbls. at 260 lbs.

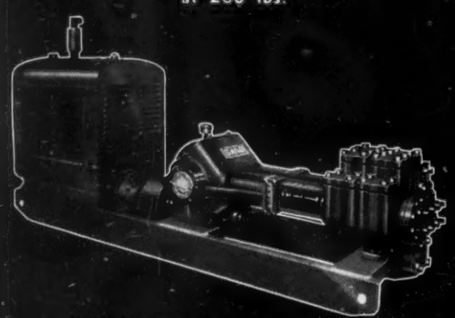


Fig. 2249. Also mounted on trailer. 46 bbls. at 750 lbs. to 126 bbls. at 300 lbs.

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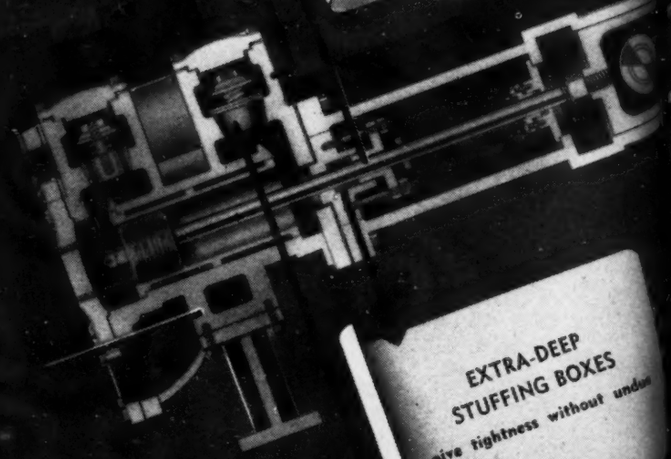

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Fig. 201. GASO Rodline Pump. 30.96 bbls. at 18 strokes, to 41.28 bbls. at 24 strokes.

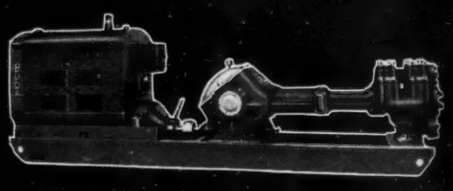

Fig. 2050-S. Portable Unit. 59 bbls. at 1000 lbs. to 255 bbls. at 250 lbs.

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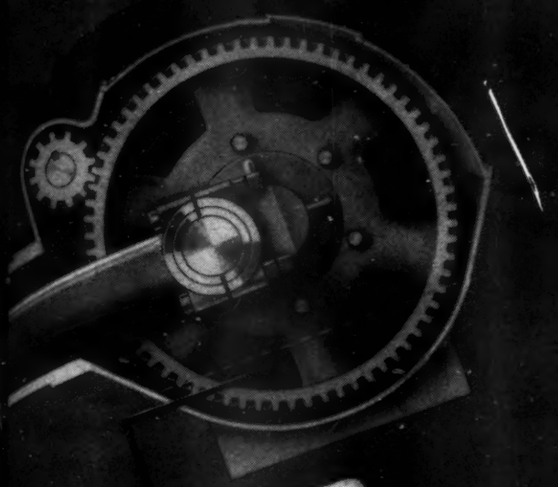
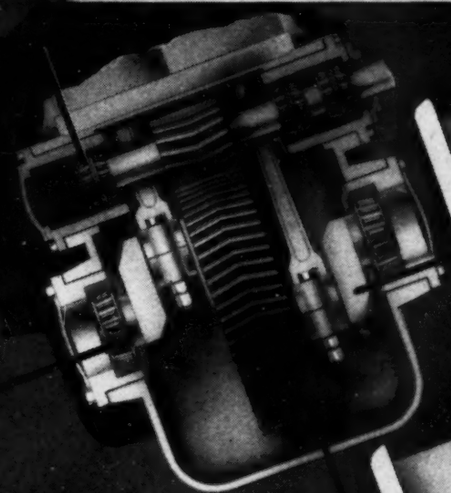


FLOOD LUBRICATION
for years, crosshead and connecting-rod bearings — by oil bath in enclosed crankcase



EXTRA-LARGE ROLLER BEARINGS
mount crank and pinion shafts, each operating in separate removable housing sealed off from crankcase oil

CRANKS SET AT 90-DEGREE ANGLE
give overlapping piston stroke, assuring smooth flow

HERRINGBONE GEARS
are center-mounted on shafts to equalize loads on bearings

PUMPS

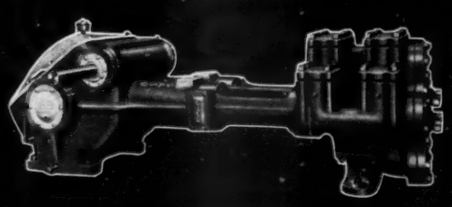
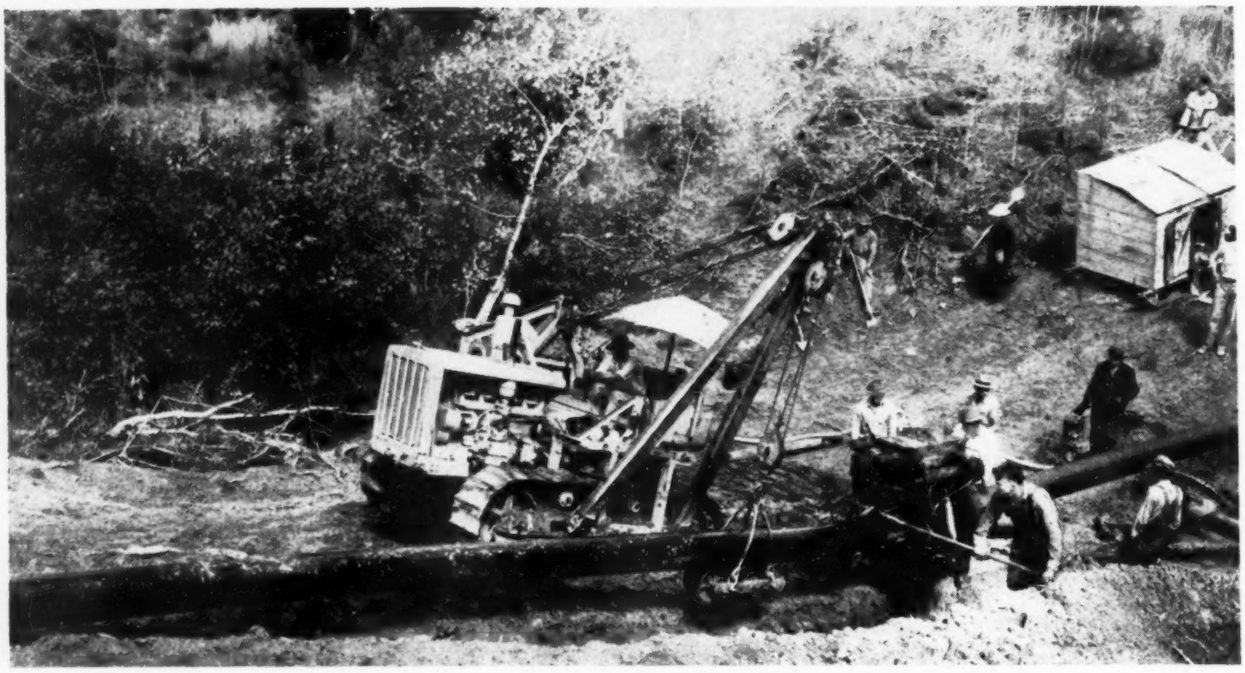


Fig. 1550. 59 bbls. at 1000 lbs. to 255 bbls. at 300 lbs.

Fig. 1849. 46 bbls. at 900 lbs. to 126 bbls. at 350 lbs.

Fig. 301. Piston Power Pump. 24 to 30-inch stroke. 31.73 to 157.36 bbls. per hour.

P 615.3
P 623.



Tractor equipped with sideboom handling 12-in. pipe for coating and wrapping machine

PETROLEUM ENGINEER Exclusive Feature

Modern Equipment Facilitates Construction of Pipe Lines

☆ **Trends and improvements in pipe-line construction methods and technique developed are marked by extensive use of machinery**

L. H. Favrot

President, Latex Construction Company

WITHIN recent years, methods employed in constructing a trunk pipe-line system have become rather well standardized, and although construction procedures have changed but little, it cannot be said that progress has been lacking. Most emphatically progress has been made. The advancement, however, has been largely with respect to improvement of existing equipment and the widening in scope of the services in which that equipment has been involved.

The laying of larger diameter and heavier pipe, the demand for increased speed in construction, and the more rigid specifications have all been factors resulting in improvements and greater use of machinery in pipe-line work. Diesel-powered equipment has come into general use. Fast, mobile equipment, automobiles, and small and large trucks equipped with power winches, are indispensable. Speed and mechanization are as much emphasized as in a modern army.

With more attention than ever before in history now being focused on the pipe-line industry because of the vital part it is playing in our war effort, it is interesting and of value to set down in chronological order the routine followed and the various steps taken to construct a pipe-line system, whether it be for the transportation of crude oil, finished products, or natural gas.

Ordinarily a contractor divides a job into different operations that are usually performed by separate crews. To

L. H. FAVROT

graduated from the University of Michigan in 1924 with the degree of A.B. with certificate in business administration—Worked for a year with Ford, Bacon and Davis after leaving school, then joined the staff of Williams Brothers Corporation—Except for a one-year period he was with that organization until December, 1936, at which time he and G. A. Peterkin formed the Latex Construction Company, Houston, Texas.

We are making a real all-out effort

It is hardly necessary for us to tell our customers that it is becoming increasingly difficult to fill their orders as promptly as we should wish. The effects of the complex influences at work in the war production program are now well understood. Our products and the materials from which they are manufactured are on the critical lists, and are subject to priority control with its unavoidable delays and disappointments.

You can be assured however that our entire organization is making a supreme effort to meet the difficulties as they arise, exerting every facility to meet the needs of your industry which is so vital to the war program. We want to stress the point that your orders today are as carefully handled as they were during those days of recent memory when our big problem was not how to meet the demand but how to keep our men employed and best occupy plant facilities.

WORTHINGTON

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General Offices: HARRISON, NEW JERSEY • Offices and Representatives in Principal Cities

implant these various steps clearly in the reader's mind before entering upon a detailed discussion of equipment generally used, it is well to enumerate them. These operations, listed in their usual order of performance, are:

(1) Clear right-of-way, grade or level right-of-way, and build temporary gates in fences.

(2) Unload, haul, and string pipe and other materials.

(3) Ditch.

(4) Weld.

(5) Line-up, bend, and lay.

(6) Clean pipe and apply protective coating.

(7) Lower pipe in ditch.

(8) Backfill ditch and clean-up right-of-way.

(9) Install casing under railroad and highway crossings.

(10) Install creek and river crossings.

It is understood, of course, that items (9) and (10) are not placed in their chronological order. These operations are performed throughout the construction of the line as they become necessary.

Right—Shooting submerged stump in swamp

Below—Making approach to creek crossing with dragline

Right-of-way

An angledozer or bulldozer blade attached to the front end of a crawler-type tractor is important right-of-way equipment for grading or leveling rough country, approaches to roads, railroads, creeks, rivers, and gulleys, and for pushing down and off the right-of-way small trees and underbrush. With a winch attachment this equipment can also be used to fell larger trees and pull stumps.

A bucket or high-lift attachment to the front end of a crawler-type tractor is used frequently. Although this piece of equipment does not have the versatility of the angledozer attachment, it is particularly useful for digging approaches to railroad, highway, and stream crossings that have a high bluff or embankment. It is used quite often for grading or leveling rough country.

Shovel and dragline equipment is occasionally employed for right-of-way work in extremely rough country, but the better traction and greater speed of tractors account for their more general use.

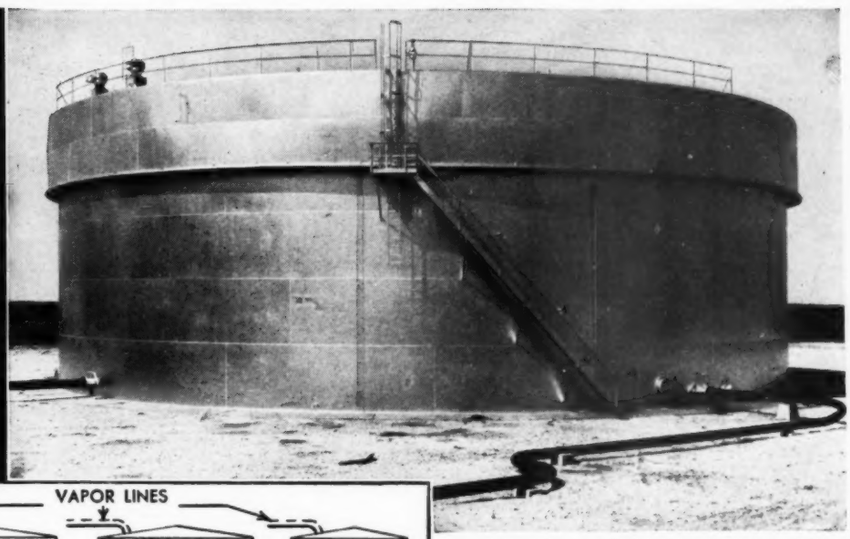
Lately a power-driven saw has been used to some extent for removing large trees from the right-of-way. To date it has not been universally tried, and its use may be said to be still in the experimental stage. Therefore, this equipment's ultimate value in pipe-line construction cannot be predicted at the present time. Removal of large trees from the right-of-way is largely done by manual labor. Removal of all tree stumps from the ditch line is required and this can be accomplished either by pulling, grubbing, or dynamiting. Whether to blast, grub, or pull stumps is determined by several factors. One important factor is the kind and size of the timber. Pines, for example, have a single root that goes straight downward. It is easier to dynamite such stumps. When the roots are shallow and of a spreading nature, however, pulling is the preferred procedure, because dynamiting would fail to remove all the roots and it would still be necessary to grub some of them by hand. The type of soil also must be considered. In sandy soil it is usually simpler to pull the stumps. Aside from these factors it must also be borne in mind that it is not safe to employ dynamite in congested areas or when a new line is being laid parallel and close to an existing line.

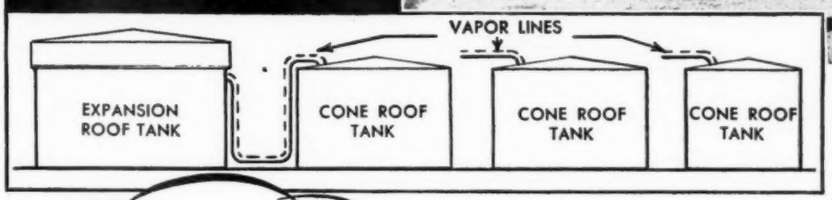
Stringing Pipe

There has been little change in the last ten years in the method of unloading and hauling pipe and in the type of equipment used. Major changes have been in the improvement to trucks and tractors. Greater use is made of trac-

GRAVER EXPANSION ROOF

STOPS LOSSES *and* MULTIPLIES SAVINGS





Graver Expansion Roof Tank. Diameter, 120 ft. Height, 40 ft. Capacity, 80,000 bbl. Roof lift, 10 ft. Expansion capacity, 114,202 cu. ft. Installed at pipe line terminal of a major oil company.

The contents of a number of cone roof tanks may be protected from evaporation and breathing losses by manifolding vapor spaces of cone roof tanks to vapor space of Expansion Roof Tank.

Millions of dollars worth of gasoline in storage is lost each year through evaporation. That this loss is needless and can be eliminated is a proven fact. It is being demonstrated month in and month out at pipeline and water terminals of many of the country's leading oil companies where Graver Expansion Roofs have been installed.

The Graver Expansion Roof is designed to hold the vapors instead of expelling them. Liquid sealed all around, it enlarges the vapor space as needed, rising and falling as the vapors expand or contract. Furthermore, if cone roof tanks are spaced reasonably close together they can be manifolded into one tank of suitable size, equipped with a Graver Expansion Roof designed to take care of the maximum breathing of the entire battery. And not only are evaporation losses eliminated, but filling losses are reduced to a minimum.

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42—1—S

Making tunnel under highway for casing and line pipe

tors for towing trucks when stringing pipe in places inaccessible to trucks dependent entirely upon their own motive power. Much greater care is taken in unloading pipe from trucks, and for this sideboom tractors, or boom trucks, are employed, depending upon terrain and size and weight of pipe.

Ditching

The use of the wheel-type ditching machine is almost universal on cross country pipe-line construction. A number of models and sizes are available, the size of trench required, the nature of the soil and country, and the length of the line determining the model of the machine to be employed. The ditching machine was one of the first labor-saving items of equipment introduced to pipe-line construction. There have, however, been innumerable improvements made to this equipment during the last 15 years.

The back-hoe shovel and the dragline find their place in pipe-line construction for purposes of digging deep ditch and cleaning out ditch. The back-hoe shovel also is employed for cleaning out "rock ditch" after it has been drilled and shot.

Two methods are most commonly used for digging ditch in rocky soil. The first is to mark-out the ditch with a ditching-machine, i.e., take out such material as a ditching machine will cut, then drill the rock with air-driven tools, and after the rock has been shot with dynamite and broken-up, clean-out the ditch with a ditching machine. The second method, and the use of this method is successful only in certain types of rock, is first to break-up the rock by pulling large plows or rooters through it with tractors. Afterward a ditching machine is used to clean-out and complete the ditch. Improvements in rock drilling equipment, perfected in other construction industries, have been made available for pipe-line work. Chiefly among these improvements are increased efficiency of air compressors and air tools, and the use of rock drill bits.

Digging a ditch in swamps or marshes presents a problem peculiar in itself. Sometimes the ditch is made by hand labor; sometimes back-hoe shovels or draglines may be used by working these machines on mats. In the case of some pipe lines laid across marshes, ditches have been cut by light wooden plows drawn by marsh buggies.

When pipe is to be laid beneath the bottom of a deep body of water or a swiftly moving stream, suction dredges generally are utilized. In shallow water, pipe usually can be buried with the aid of air or water jetting equipment, small suction pumps, a dragline with clamshell bucket mounted on a barge, or a derrick barge with clamshell bucket.

Welding

One of the greatest improvements in pipe-line construction operations has been in the field of welding. This applies to welding equipment, welding rod, and welding technique. Truly astounding records have been made in this field. Inasmuch as a great deal has been written and said on the subject of welding, for that reason making virtually everyone familiar with the equipment available, the writer will not attempt to discuss that phase of pipe-line construction.

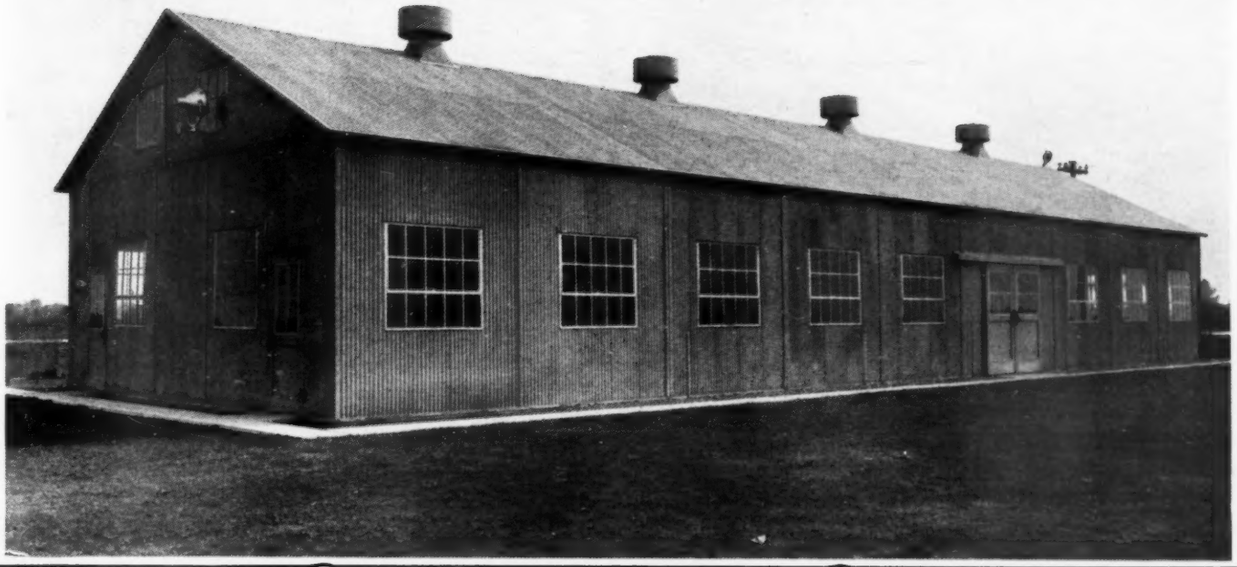
Lining-up, Bending, and Laying

Crawler-type tractors equipped with sideboom and winch are now almost universally used to handle joints or sections of pipe of all sizes. The equipment serves to place pipe on skids over the ditch, line-up pipe preparatory to welding, and to bend pipe. Tractors and sidebooms are built of sufficient strength that one tractor, with bending block attached, can cold bend small-diameter pipe. To bend pipe of large diameter two tractors of this type are required. There is a limit to the size of pipe that can be bent cold, depending upon wall thickness and hardness of the steel. Usually it is not practicable to cold bend pipe of greater diameter than 20 in. When cold bending cannot be accomplished successfully, fire bending becomes necessary, either with or without the use of wrinkles. In the case of extra-large diameter pipe, factory bends are sometimes welded into the line.

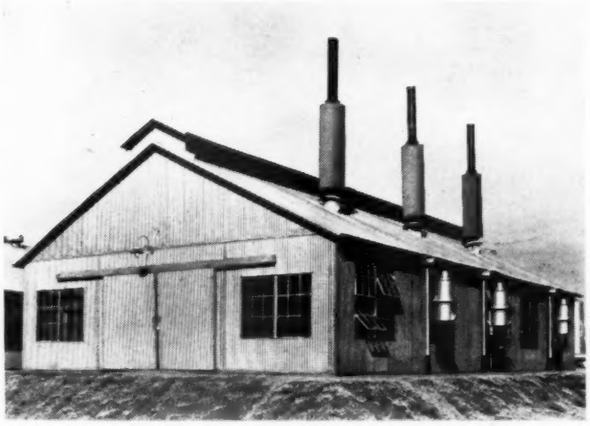
In laying large-diameter pipe there are certain conditions under which draglines are very useful in handling sections of pipe. This is especially true in the laying of stream and creek crossings.

Cleaning and Coating Pipe

Equipment available for cleaning pipe and applying protective coating represents a continued effort on the part of a small group of men. Cleaning and coating are highly specialized jobs, and the extent to which these men have succeeded is apparent in the quality of the work, speed, and cost of cleaning pipe and applying coating that is now possible. Equipment is available for cleaning pipe, new or old, in single joints or in a continuous line, with the pipe in or out of service. The machine, self-propelled, makes use of a split head encircling the pipe, which contains spring-mounted steel knives, cutter wheels, or wire brushes. A further development is a priming attachment that is used in conjunction with the



BRADEN PIPE LINE STATIONS



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Every Braden Building has these important features and advantages that cost no more: Complete Suitability to the purpose for which designed—Maximum Durability and Safety—Elimination of Obsolescence of the Building—Decrease in Time Required for Erection—100% Portability and Salvage.

See 1942 Composite Catalog, Pages 392-3

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BRADEN STEEL

Angledozer moving rock and earth in mountainous country

cleaning machine, and a priming machine designed to operate independently of the cleaning machine.

Equipment that originally was designed to apply only melted asphalt, coal tar, and grease paints to pipe, has been so developed that now it not only will apply these coatings, but in the same operation will wrap the pipe with felt and paper material.

For the traveling-type cleaning and coating machine to operate most efficiently, a sideboom crawler tractor is necessary to lift the pipe high enough for this machine to clear the ground and skids. The pipe is raised to a height of about 3 ft. above the ground and the tractor moves forward while holding the pipe suspended. A pipe cradle is held by the tractor; this cradle consists of rollers on which the pipe rests.

Efficient and economical operation of a coating machine requires an uninterrupted supply of melted coating material, which is made possible by an ample number of large-capacity portable paint kettles.

An alternate method of coating pipe is to apply the coating in a central yard or plant where stationary type equipment is employed. These yards usually are situated near rail points and with regard to accessibility of right-of-way. Ordinary pipe trucking equipment is used in hauling coated and wrapped pipe except for the use of padding and taking other precautions to protect the coating.

Lowering Pipe, Backfilling, Etc.

Sideboom tractors and trucks and winch-operated tripods are the several means employed for lowering pipe into the ditch. Circumstances dictate the method. Under ordinary conditions the sideboom tractor is the most generally used equipment.

Both angledozer tractors and the bucket-type, winch-operated sideboom tractors, are employed in backfilling ditch, the type depending largely upon the nature and dryness of the soil and the character of the country.

Special tools and machines have been devised and are now in use for boring and jacking casing pipe under railroads and highways.

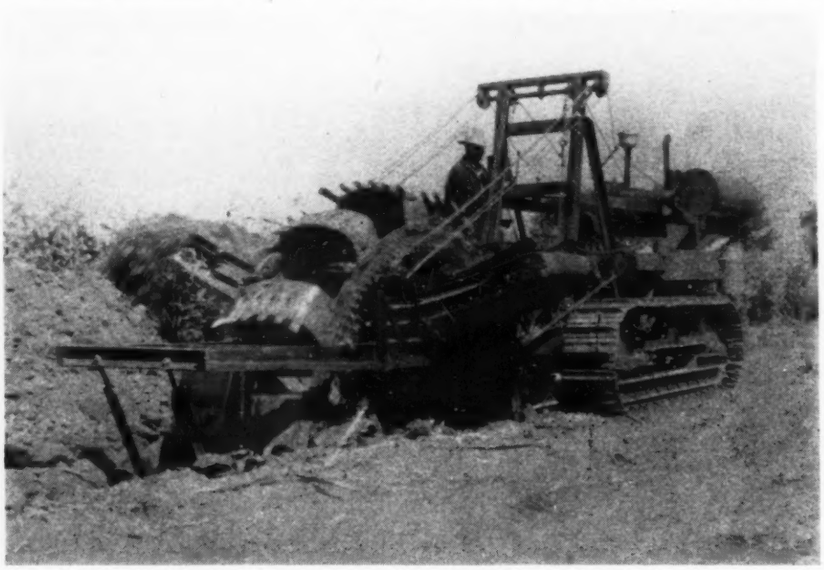
Some of the same equipment used in other operations is also employed in laying pipe across creek and river crossings. Unless the crossing is too wide the sections of pipe are welded on dry land and pulled into place in the water. If the water crossing is wide, the pipe is laid from barges, each section being welded-on as the pipe is lowered.

Conclusion

In normal times, there are relatively few pipe-line construction operations that are not continually undergoing some change. These changes are always in the nature of improvements over previous practices and methods. In the present national emergency, the demand for greater speed and restriction in the use of critical materials in construction may profoundly affect pipe-line construction methods and practices. Pipe-line transportation has become an extremely essential and important branch of the industry, hence the construction of new additions to the nation's network of pipe lines may be expected to accelerate progress both in technique and equipment.

——☆☆☆——

Ditching machines are universally used in cross-country pipe-line construction



P 615.635.4

Cathodic Protection Installation Carefully Engineered

PETROLEUM ENGINEER Exclusive Feature

Requirements for protecting pipe line laid in soil of varied chemical content determined by more than 50,000 tests made of resistance and potential difference

by Chas. F. Ofner

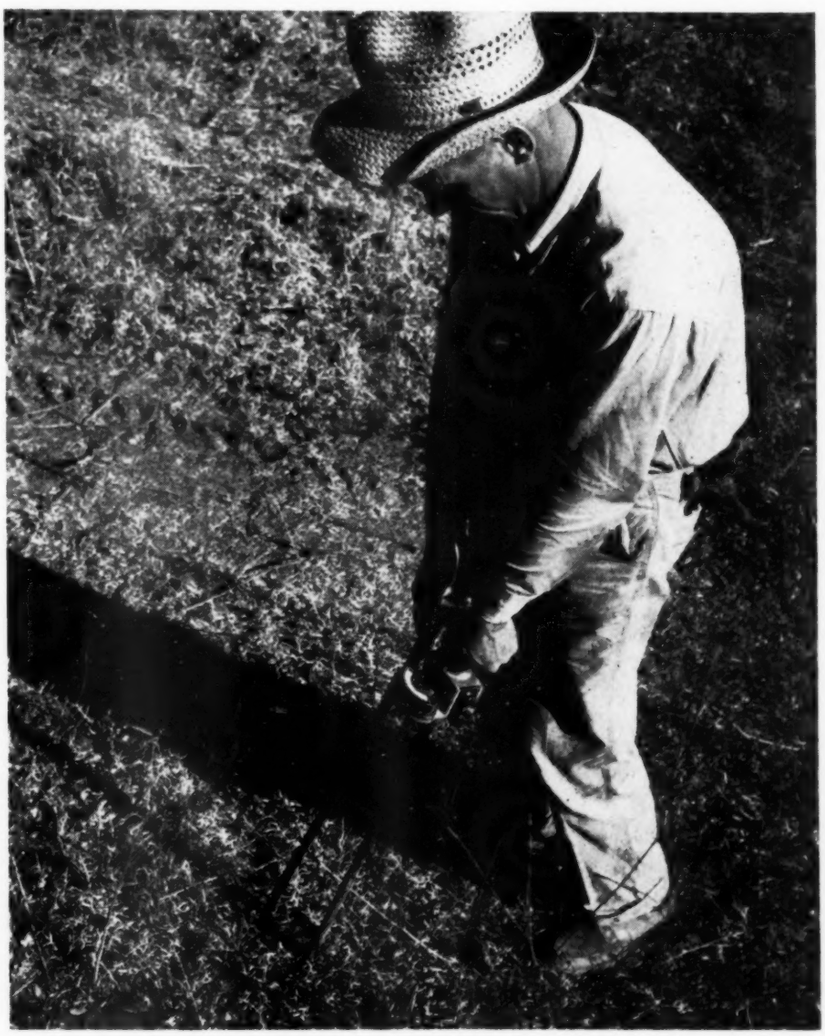
Industrial Engineer, Houston Lighting and Power Company

ONE of the most interesting of the many recent installations for corrosion mitigation by cathodic protection is that nearing completion by the Shell Pipe Line Corporation on the Houston terminus of its West Texas line. The project is the continuous protection of 54 miles of 10-in. line.

The portion of the line that is protected passes through the country adjacent to Houston. Rural type 6900-volt distribution lines of the Houston Lighting and Power Company form a network over this area.

Shell Pipe Line Corporation engineers, recognizing the dependability of electric service for this application, have taken advantage of this network by placing rectifier units at many points along the line where electric distribution crosses the pipe-line right-of-way.

Through coöperation with the industrial sales department of the Houston Lighting and Power Company, this plan was so effectively put into practice that in the protection of the 54 miles of line through 24 points of service, a total of scarcely five miles of new electric distribution was required. Because the soil in the area is of varied chemical content, it was necessary to carry on a great amount of testing before actual installation was begun. In many places along the line there are so-called "alkali spots" that have been



Making soil resistivity measurements with a Shepard's Cane

CHAS. F. OFNER

was graduated in electrical engineering from the Rice Institute, Houston, Texas, in 1936—He entered the commercial power sales department of the Houston Lighting and Power Company the same year and was transferred to the industrial power sales department in 1938—For the last two years he has devoted all his time to the oil producing and pipe line companies served by the Houston Lighting and Power Company in his present capacity as industrial engineer.

Making up connection to ground bed

a major source of trouble. These are areas, some of which are no more than an acre in extent, in which the soil is highly basic. They are easily identified in a freshly plowed field by their yellow color. The spots are also discernible in cultivated fields by their lack of vegetation.

The line also passes through the Pierce Junction oil field where much salt water has been allowed to seep into the ground. This area caused so much difficulty with leaks that a cathodic protection unit was placed in service there in 1936, four years prior to the inception of the plan for the continuous protection of the line. Many of the data in this article have been taken from the performance of this unit.

Tests Made

Tests were begun early in 1940. Measurements of resistance and potential difference were made at 100 ft. intervals along 95 miles of the line. Pipe line company engineers estimate that more than 50,000 holes were drilled to pipe line depth to take these readings.

Ground resistivity measurements were made with a "Shepard Cane," an instrument that reads directly in ohms per cu. cm. Voltage measurements were taken with a potentiometer.

These observations were plotted to scale along the pipe line and calculation for requirements were begun. It is interesting to note that several leaks that occurred later were predicted after this plotting was done. Locations where potential difference to ground was found to be especially large were suspected areas and leaks actually occurred later in a number of these spots.

Placing the Rectifiers

Tentative placing of the rectifiers was then undertaken. This proved to be a job of combining three factors. First, the resistance and potential readings demanded a certain amount of current for counter action. Second, the current must be supplied by standard rectifier units, easily obtainable and interchangeable, instead of by custom-built units. Both conditions must be satisfied in each case and, third, the location must be readily accessible to a power line. At the first attempt this appeared to be a somewhat difficult task but experience proved it a great deal easier than expected.

After these locations had been made, field checks definitely to choose the sites were begun. For this work two engine generator sets mounted on trailers for mobility were employed. These units were set-up at points tentatively chosen and temporary ground beds of copper ground rods were connected. They were then adjusted until they were delivering 40 amp. Next potentiometer readings were taken from pipe to ground along the line between units and the distance between units was adjusted until a minimum reading of 850 mv., using a copper sulphate electrode, was observed at all points. One machine was then moved ahead along the line to the next tentative place and the procedure was repeated until all locations had been established.

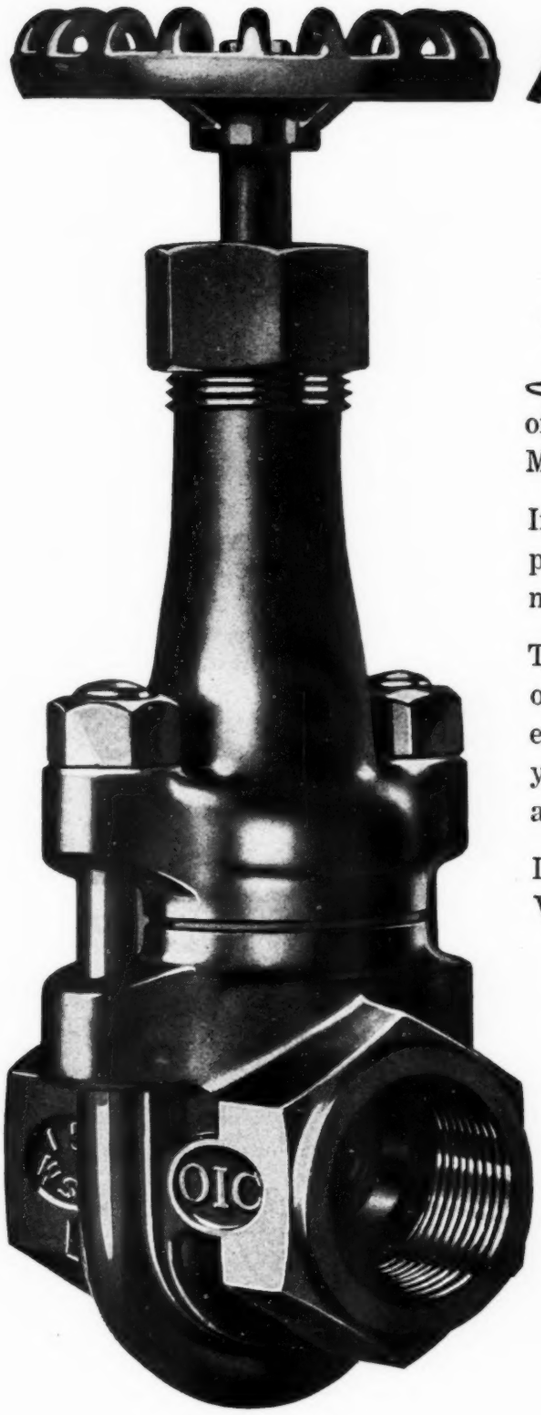
Installation Standardized

After all necessary rights-of-way had been obtained, actual installation was begun. Standard practice on each location was employed so that all equipment is interchangeable and easily obtainable. Rectifier units were mounted on poles and were provided with an externally operable switch. Ground beds used are large scrap cast-iron pieces obtained from local junk dealers. Conductivity to soil was improved by the use of gypsum and rock salt. These ground beds were connected to the rectifier with 1-0 cable having moisture resistant insulation A shunt was installed in series with each ground bed and the leads were brought to the surface through a 1-in. pipe so that easy checks may be made of the bed's effectiveness at any time. These beds were installed and treated so that 40 amp. will flow when 12 volts is impressed. This means that because of different soil conditions the amount of iron used varied widely throughout the installation.

The rectifiers used are of the copper oxide type, chosen because of their inherent reliability and long-life characteristics. They are equipped with a transformer rated at 115/230 volts on the primary side and provided with taps on the secondary side to give a range through 50 percent of the normal output. A d-c. ammeter and voltmeter are incorporated in the unit for ease of adjustment. The entire assembly is contained in a weather- and insect-proof case fitted with hangers for pole mounting. A fan of low rating is used for cooling the unit and thereby increasing its efficiency.

This type unit has proved very satisfactory as it requires no attendance, works safely, and, most important in this kind of service, performs without interruptions.

It is interesting to note the spacing that was required on this project. The distance between units varies from a maximum of 4.7 miles to a minimum of 0.9 mile. Figures show, however, that due to different conditions of soil and pipe covering, energy consumption for all units is very nearly equal.



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ASK FOR
FIGURE 333

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Experience With Older Unit

This system has not been in service long enough to permit discussion of its effectiveness but an idea of what may be reasonably expected is given by the experience with the unit in the Pierce Junction oil field. Here frequent repairs to pipe were required at more or less regular intervals and about every three years it had been necessary to take the pipe from the ground, "dope" it and bury it again At the time the rectifier was installed in 1936, such a reconditioning job was about due to be undertaken. This, however, was postponed awaiting the results of the cathodic protection installation. All trouble was immediately eliminated and the line has not yet required reconditioning.

Such performance is indicated by the new installations as a sharp drop in the number of leaks occurring has been experienced since the first units of the new system have been in service.

Before going into consumption figures, it might be well to give a brief description of the line and its condition. The pipe is 10 in. in diameter and was laid in 1928. It had originally an asphalt coating and aside from local treatments has had no reconditioning. The soil, being on the Gulf Coast plain, is generally moist. Much of it is cultivated in rice and this requires flooding of the land.

Power Consumption

For the units now in operation, a month chosen at random indicates that the protective system varies in consumption from 400 kw-hr. per mile per month to 145 kw-hr. per mile per month. The average over these units is 254 kw-hr. per mile per month. All these figures are total consumption figures and include losses sustained in the rectifier units themselves.

Kilowatt-hour consumption figures on the unit in the Pierce Junction oil field show that there is not a great deal of variation from month to month as might be expected. There is a maximum variation of about 10 percent from year to year, presumably due to climatic conditions. Kilowatt-hours consumed in 1941 by this unit follow:

	Kw-hr.
January	557
February	484
March	542
April	541
May	514
June	515
July	520
August	547
September	503
October	501
November	445
December	390

Again, these figures include losses in the rectifiers. Some distortion is brought about because all the months do not contain the same number of days. Experience with this project has encouraged the Shell Pipe Line Corporation to extend protection to other parts of the line involved in this project as well as to other lines in the system.

The practicability of this plan has been definitely established by this project. The advantages of utility company service have been obtained through the multiple point of service installation with the minimum investment in new electric lines.

This feature is of particular interest and importance at this time in view of the necessity for conserving materials. During the last several years many power companies have built hundreds of miles of rural lines until in some areas traversed by pipe lines the electric distribution system forms quite a close network so that service for rectifier units is available from a nearby supply at almost any location.

In the planning of rural lines by the power companies the economic justification; that is, the revenue-bearing possibilities, determine whether or not the line should be built. Frequently in very sparsely settled areas the potential residential usage of electric service is not great enough to support any considerable expenditure of line construction. The inclusion of one or more services to rectifier installations, however, might easily warrant the extension. It is seen, therefore, that if the long range possibilities of cathodic protection and consequent rectifier installations were made available to the power companies, considerable impetus would be given to expansion of rural distribution systems with mutual advantages to rural residents, pipe-line companies, and power companies.

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Typical installation of rectifier

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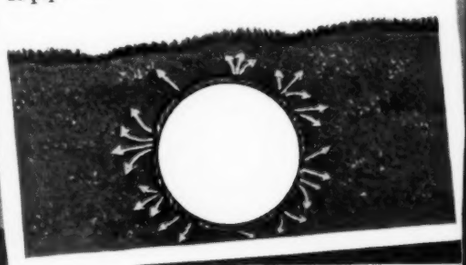
Electrolytic action between metal pipe line and soil or water. Result—corrosive deterioration of pipe line.



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Co-ordinating Electric Pipe-Line Pumping Equipment

PETROLEUM ENGINEER EXCLUSIVE Feature

Comparison of torque-speed curves of pumps with torque of proposed motor, and knowledge of power supply characteristics are essential factors in designing stations equipped with electrical prime movers and centrifugal pumps

by W. G. Taylor

Industrial Engineering Department, General Electric Company

ALTHOUGH a large number of electrical pipe-line pumping stations have been installed throughout the country, there are several factors requiring specific thought and planning on every new project involving electric drive. These are not matters that may be standardized, as they depend on the pump design, the characteristics of the electric power supply, or the preferences of engineers responsible for the project, although they concern the selection of standard apparatus. One of the most important factors is the interrupting capacity required to handle and clear short circuits successfully.

Interrupting Capacity

The interrupting capacity needed is determined by the amount of power available from the power system, the current-limiting effect of the transmission and distribution lines, and the electric apparatus through which current flows between the source of power and the point at which a fault occurs. Power systems have grown to a point where short-circuit current in many cases has become a very important consideration in the selection of suitable control equipment. Likewise, increasingly large horsepower requirements of major pipe-line pumping stations will correspondingly decrease the current-limiting effects of feeder and power transformers, thereby increasing the possible short-circuit current.

It is essential for success that, under fault conditions, the switching apparatus be capable of automatically opening the circuit without serious damage to itself, and that other apparatus through which fault current may flow will not be damaged during the time required to open the circuit. The damaging effect of high current is due not only to heating and burning but also to heavy magnetic forces produced.

Obviously, the cost of protection against the effects of heavy fault currents increases with the amount of such current involved, and hence, from the economic standpoint, it is necessary to study the projected layout to determine the least expensive equipment that will effectively cope with such conditions. It is unsafe to apply switching equipment blindly in this respect, especially for large stations, as failure might seriously impair the pumping service as well as be very expensive for repairs. Standardization of layout is not generally practicable. Especially is this so for major pipe lines, because they will usually traverse the territories of several central-station power systems or more than one division of the same system. Accordingly, the power supply for the various pumping stations will come from different sources or be influenced by different factors under fault conditions.

W. G. TAYLOR

has been an industrial application engineer with the General Electric Company for many years, specializing since 1911 on the oil industry in its production, pipe-line, and refining branches, and identified with most of its major electrical problems and developments—A native of New York State, he graduated from Cornell University in 1907 as a mechanical and electrical engineer, with previous mechanical training in machine and locomotive repair shops—After taking the General Electric test training course, he served for several months as assistant engineer of distribution in the New York and Queens Electric Light and Power Company at Long Island City, New York, and then returned to General Electric—He is licensed as a professional engineer by the State of New York.

Although a power source may be of large capacity, the available short-circuit current at the point where motor protective switching is to be installed may be only moderate, due to the current-limiting effect of the intervening electrical circuits, transformers, etc. This effect invariably produces a drop in voltage. As will be explained more in detail later, it is very important that this voltage drop be insufficient to impair seriously the ability of the motor to start and accelerate the pump to full speed successfully. There is, therefore, a practical limit to the amount of current-limiting effect that can be tolerated, and consequently a pumping station will almost always require switching equipment of higher grade than that merely capable of carrying full load current and having only low interrupting capacity.

Circuit breakers and magnetic contactors differ materially in their characteristics and this must be considered in coördinating the control equipment for any specific pipe-line pumping installation. The contactor within its operating range opens a circuit in a much shorter time than a circuit breaker, but has relatively low interrupting capacity. The circuit breaker, though slower, can be built for any high interrupting capacity required. The contactor, furthermore—except the latched-in type—is held closed only magnetically, and the opposing magnetic effect of high fault currents may force the contacts open and cause burning. The latched-in type is held closed mechanically and the contacts cannot be forced open magnetically. It can be built for high interrupting capacity, but is available only in the larger sizes, is more expensive, and has

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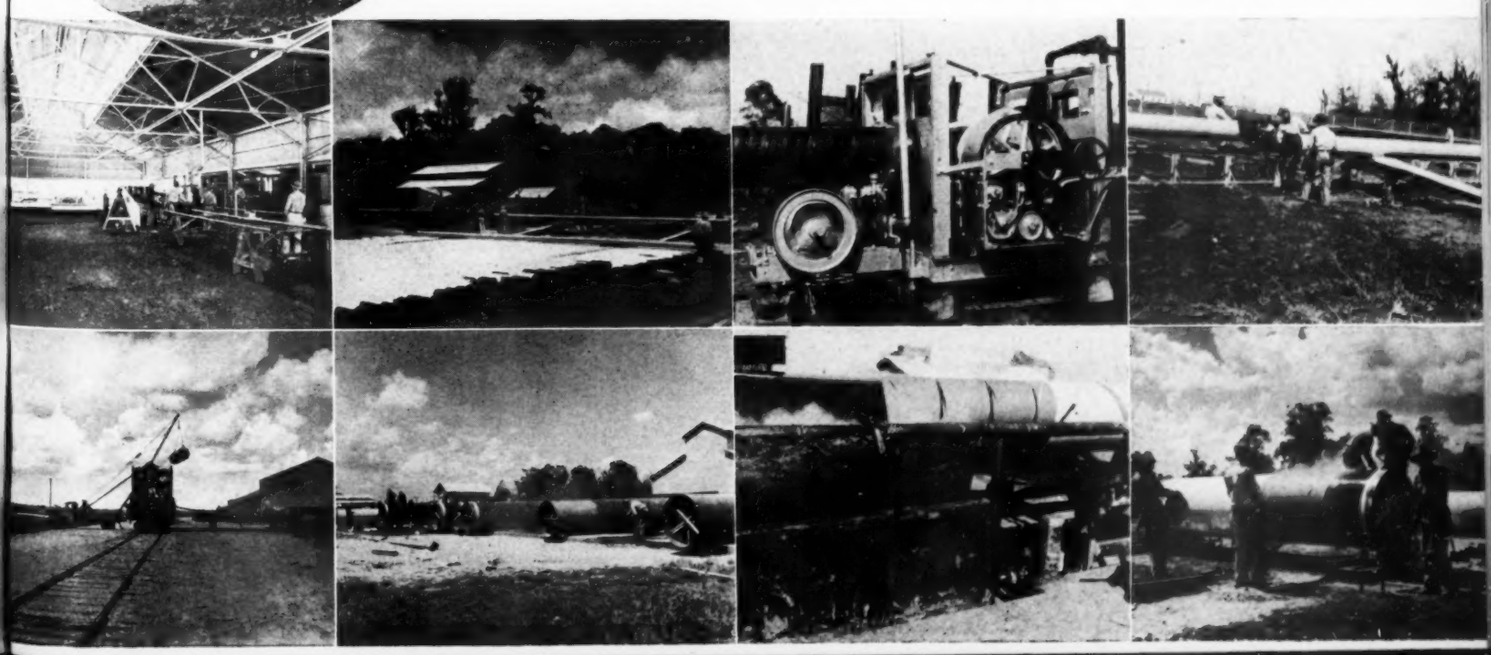


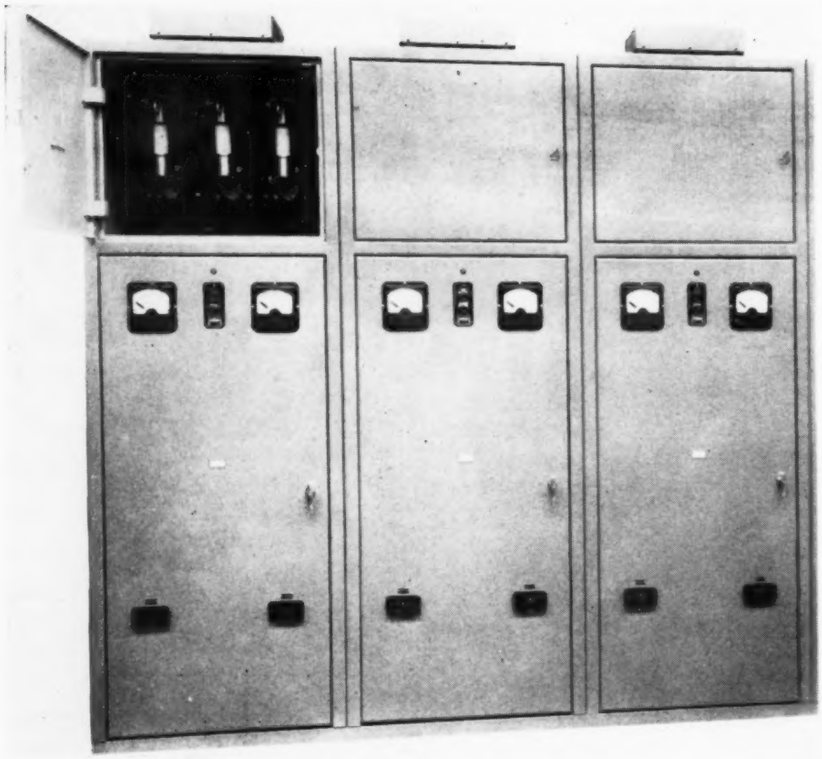


Fig. 1. Unit control assembly of three 2300-volt, full-voltage magnetic motor starters with current-limiting fuses incorporated in each for short-circuit protection

a relatively short life as compared with a conventional contactor.

These characteristics make it evident that a main-line circuit breaker with ample interrupting capacity will not adequately protect a magnetic motor starter with clapper-type contactors, as fault current may rise sufficiently to cause the contactor tops to be forced open with resulting damage before the breaker has time to open a short circuit. There are, however, three ways of obtaining suitable protection, as follows:

1. Use circuit-breaker starters for each motor. This is practicable only when starting is infrequent, as a circuit breaker is not designed for frequent operation. Starting of pipe-line pumps generally is sufficiently infrequent to permit such use without excessive maintenance.

2. Use a latched-in contactor-type starter for each motor, provided it is available for the required interrupting capacity, motor size, and voltage.

3. For each motor use a combination magnetic-contactor type starter in which are incorporated the new and highly successful current-limiting fuses (Fig. 1). These have high interrupting capacity, and are now available for 2300 volts and for a present upper limit of motor rating varying from 300 to 700 hp., depending on the motor characteristics. Separate disconnecting switches are unnecessary, as the fuses and their supports are designed for disconnecting service.

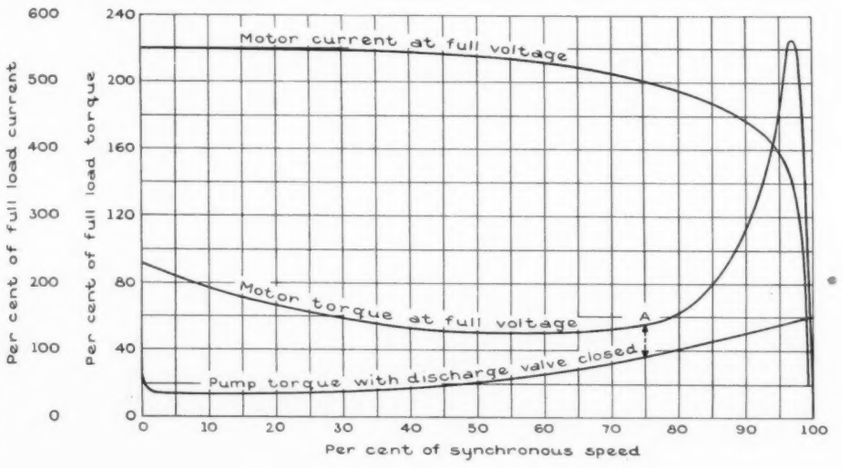
This last arrangement, using starters equipped with current-limiting fuses, has the advantage of relatively low cost, particularly when high interrupting capacity is needed. This type of fuse in the sizes usually selected for pipe-line stations will successfully interrupt fault current on a 2300-volt line having an available short-circuit capacity on the order of 150,000 kva. Its action is faster than that of an ordinary fuse. It cuts off fault current in less than ¼ cycle (1/240th of a second), which is before a dangerous level of current is reached, and the short-circuit is cleared in less than ½ cycle (1/120 second), limiting total energy to a low value. Because these fuses act so fast and hold the current to a relatively low value, they adequately protect the clapper-type contactors in the starter by making it unnecessary for the contactors to withstand the full short-circuit current that can be supplied by the feeder. Because their high interrupting capacity is almost never exceeded by the requirements of a pipe-line pumping station, they permit a uniformity of protection in all stations at moderate cost, and thus practically eliminate the necessity of a detailed study of the short-circuit protection required at each station.

Current-limiting fuses are selected to operate only under actual short-circuit conditions, and will not blow unnecessarily. Their current-limiting effect develops only on short-circuit current, and they do not produce any drop in voltage under normal starting and running conditions. They are dry, enclosed and sealed, and operate silently without emission of gas, flame, or vapor, and without discharge of metal, and give a visual indication if blown.

Incoming-Line Circuit Breaker

An incoming-line circuit breaker is recommended for the station, both to provide overload protection for the transformers and to provide means for disconnecting the station bus from the power supply. Disconnecting switches alone should not be used for the latter

Fig. 2. Representative accelerating torque and current characteristics of a 3600-r.p.m. centrifugal pipe-line pump unit with squirrel-cage induction motor



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purpose, as they are unsuitable for breaking the magnetizing current of auxiliary transformers that might be connected to the bus.

In some cases the power company will supply the main transformers and the protective circuit breaker, and usually will not permit the pipe-line company to operate or control the breaker for any purpose. It is then advisable for the latter to install an additional main-line breaker for the purpose of bus disconnection and protection, thus putting these functions under the control of the station operator. This breaker will serve also as a means of readily "killing" all power circuits in an emergency.

If the pipe-line company supplies the transformers and is therefore responsible for their protection, then one incoming-line breaker can serve all purposes.

In the event of a fault in a motor circuit, it is more desirable to isolate that circuit than to shut down the entire pumping station. Adequate interrupting capacity in the starter for each motor circuit makes this possible. Attention must be given to the selection of suitable overload relays so that, if such a fault occurs, the main breaker will not trip, and yet will open if a short-circuit occurs between the starters and that breaker.

Motor Starting Torque

Reciprocating pipe-line pumps offer no particular starting problem, as the pump can be, and usually is, bypassed, and either a squirrel-cage or a wound-rotor induction motor will start and bring it up to full speed readily. Centrifugal pumps driven by wound-rotor motors likewise present no starting difficulties.

When centrifugal pumps are driven by squirrel-cage induction motors, it is necessary to make sure that starting conditions will permit the motor to bring the pump promptly and fully up to speed. It is especially important to check this if the motors are 2-pole machines, which have a synchronous speed of 3600 r.p.m. on 60-cycle power, or 3000 r.p.m. on 50 cycles. With motors of lower speeds this problem also exists, but usually to a lesser degree. This matter ranks with the determination of required interrupting capacity as one of the most important factors for consideration to insure successful operation.

During starting, the high-speed centrifugal pump, if driven by a squirrel-cage motor, must have its discharge valve closed, or at most only slightly cracked open. Even when the valve is closed, the torque the pump requires increases as the speed rises, and at full speed is usually from 30 to 60 percent of full-load torque, depending upon the design of the pump. Induction motors are so designed that, if the voltage applied to the motor is not less than its rated voltage, it will successfully bring the pump up to full speed under these conditions. If, however, the voltage at the motor is lower, either because of voltage drop in the line due to starting current, or because the reduced-voltage method of starting is used, the motor torque delivered will be reduced, the torque varying in proportion to the square of the voltage. Successful starting requires that even under such conditions the available motor torque, at all speeds up to full speed, must be in excess of the torque required by the pump, so that there will be a margin available to continue the acceleration. The less the margin, the longer it will take to get the pump up to full speed, and if at any reduced speed the margin disappears, the speed will stick at that point. Such a situation must, of course, be avoided.

Fig. 3. Gasoline pipe-line pumps, driven by 150-hp., 1800-r.p.m., totally-enclosed, fan-cooled, squirrel-cage, explosion-proof and weather-proof induction motors, installed in Texas

The 2-pole induction motor inherently has accelerating torque characteristics that make it necessary to check these starting conditions carefully in advance. Up to about 75 percent of full speed, its torque remains approximately constant or may even drop somewhat at intermediate speeds, but at the same time the required pump torque is going up at an increasingly rapid rate, as illustrated in Fig. 2. The point at which the pump torque curve most closely approaches the motor curve is about 2600 to 2800 r.p.m. on a 3600 r.p.m. motor, as indicated at A in the illustration. If the motor torque is too low, either because of line drop or too low starting voltage, the speed will stick at this point. If this should happen after an installation has been made, the only simple remedy would be to increase the starting voltage or raise the line voltage, which might be impracticable.

To insure success in starting, it is accordingly necessary to determine the conditions in advance. This requires examination of the pump curve showing the torque required during acceleration with the discharge valve closed.

Method of Starting

When full-voltage starting is planned, it is essential that the starting current must not produce excessive voltage drop in the line. This is still more important when the reduced-voltage-starting method is used, as even less line drop can be tolerated. The latter method produces less drop because the line current is reduced, but this favorable effect on motor torque is more than offset by the unfavorable effect of this starting method. Because of this, it may not be practicable to start at reduced voltage on some power feeders.

The purpose of starting a motor by the reduced-voltage method is to lower the starting current peaks and thus minimize voltage disturbance on the power line. During the starting period there are two such peaks, one at the instant of starting and one other when the motor is switched directly to the line. To keep the latter peak as low as

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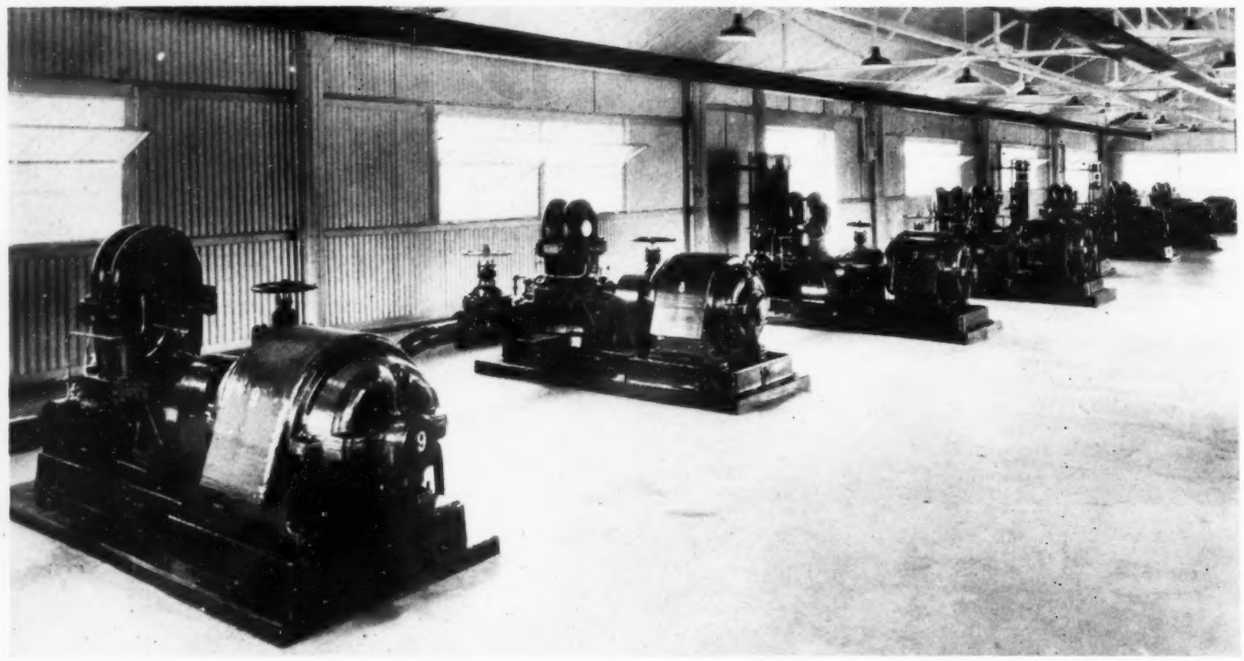

Fig. 4. Oil pipe-line pumps, driven by 250-hp., 3600-r.p.m., squirrel-cage induction motors

the first one, the motor must remain on the starting connection until it has accelerated to nearly full speed. By reference to the curve in Fig. 2 showing the approximate full-voltage starting current of a 2-pole induction motor, it is apparent that this current remains high until the motor has accelerated well above the speed (point A) where the torque developed by the motor most closely approaches that required by the pump.

If the reduced-voltage starter should be adjusted to switch the motor to the line before the speed has reached point A, the current on the second peak would jump to that shown on the full-voltage curve at the speed where this switching took place. The curve shows that this peak would be more than approximately 500 percent of full load current, which is much higher than the first peak would be, and nearly as high as when the motor is started at full voltage. It would be a fallacy, therefore, to expect that any advantage would be gained by starting at reduced voltage with the starter adjusted to switch the motor to the line at a speed below that at point A, so as to avoid the possibility of the speed sticking there. A full-voltage starter would be cheaper and would give practically as good results.

When the power system is so "soft" at the location where it is proposed to install a pipe-line pumping station that excessive voltage drop is indicated with either method of starting, a power feeder of large capacity, perhaps with larger transformers, is the remedy. Such a change will increase the necessary interrupting capacity of the switching equipment. Conversely, it is not always practicable to reduce fault currents by current-limiting devices, such as reactors, to a point where switching equipment of low interrupting capacity may be used, as they may produce excessive voltage drop under starting conditions.

Hazardous Gas Conditions

Whether a pipe-line station is handling crude oil or gasoline, one should foresee the possibility of a hazardous condition arising from the presence of explosive gases. This problem is largely up to the designer of the station, and may be taken care of in several ways.

Motors suitable for Class 1, Group D, hazardous locations (as defined by the National Electrical Code) may be installed in the pump room or in any place where explosive gases at times may be present. (Fig. 3). Pipe-ventilated motors, obtaining their ventilating air from a safe source outside, are sometimes used, but their protection is not entirely adequate. In case of a fault inside the motor, any sparks or flames that might be produced are not prevented by pipe-ventilated frame construction from getting outside, and combustion inside will be supported by the ventilating air. Better protection is obtained with inert-gas-filled motors having a closed, water-cooled ventilating system. These may be obtained in larger sizes than so far available in approved Class 1, Group D construction.

Some pipe-line companies prefer to use open motors. (Fig. 4). If there is any possibility of a gas hazard, such motors should be coupled to the pumps through a fire wall. (Fig. 5). This permits the locating of both the motors and the control equipment in one well-ventilated room, suitably sealed from the pump room.

If the main motors are in the pump room, the control equipment is safer in a separate ventilated room, situated preferably at the far side of the station from the pumps. This would make a better arrangement and probably require less investment than the use of explosion-proof starters for the main pumps, as the incoming-line panel and metering equipment would still require isolation in a control room. The control room will be better protected if situated on the windward side of the pumping station with respect to the pumps and manifolds and the prevailing wind.

Auxiliary station-pump motors and starters suitable for Class 1, Group D locations make it possible to place such equipment where most convenient for operation, without sacrificing safety.

Station Ventilation

Considerable heat is produced by the motors in a pipe-line pumping station and this is in many cases more than sufficient to heat the motor room. Ample ventilation must therefore be provided to remove this heat in summer and control it at other times, so as to avoid a high ambient temperature for the motors as well as to make the station comfortable for the opera-

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tors. The amount of air required for sufficient room ventilation will be more than that which circulates through the motors, if the heat produced by them is to be disposed of satisfactorily, and may be roughly estimated as 12 cu. ft. per min. per installed motor horsepower.

Unit Substations

In connection with any specific pipe-line project involving the supply of electric power from several public utility companies, it is very probable that these companies will differ in their preferred incoming-line arrangements at the various stations. As previously mentioned, the power company may supply the transformers and meter the power on the secondary side, or the pipe-line company may be expected to buy primary power and supply the transformers. In some cases suitable transformers may be available, making the purchase of new ones unnecessary. In most cases, however, there is the probability that completely new equipment will be needed, and it is possible that all of it will be purchased by either the utility or the pipe-line company. In such cases, the modern unit substation makes an excellent installation. (Fig. 6).

Unit substations are complete and ready to install, with all parts fully coördinated by one manufacturer, assuring successful, dependable performance. All live parts are metal-enclosed. These substations are shipped in one or more complete sections, ready to bolt together and connect to the power cables. Their compactness saves space and they present a much better appearance than equipment assembled piecemeal. Standard unit substations offer a choice of incoming-line arrangements.

Lighting and Auxiliary Power Circuits

A relatively small matter, but nevertheless important, is the source of power for station lighting. If the lighting transformer is connected to the power circuit on the load side of the incoming-line breaker, there will be no lights when the breaker is open, unless provision is made to supply emergency lighting from a storage battery. This is obviously undesirable. The lighting transformer preferably should be connected on the incoming-line side of the breaker, to assure the maintenance of lighting in an emergency. It is usually mounted outdoors. Provision for safety can be made by using vapor-proof lighting fixtures and an approved method of wiring.

With lighting power obtained ahead of the main breaker, it is necessary to use a separate bank of transformers to supply low voltage to auxiliary motors, so that they may be connected to the load side of the main breaker and thus be disconnected in an emergency shutdown of the station. These transformers may be mounted indoors or out, as preferred.

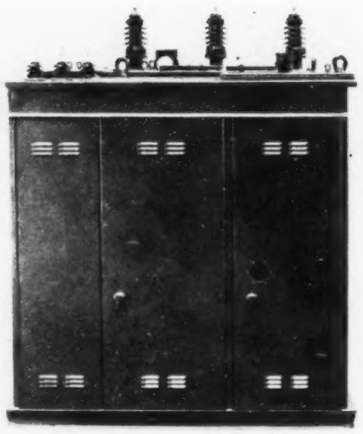
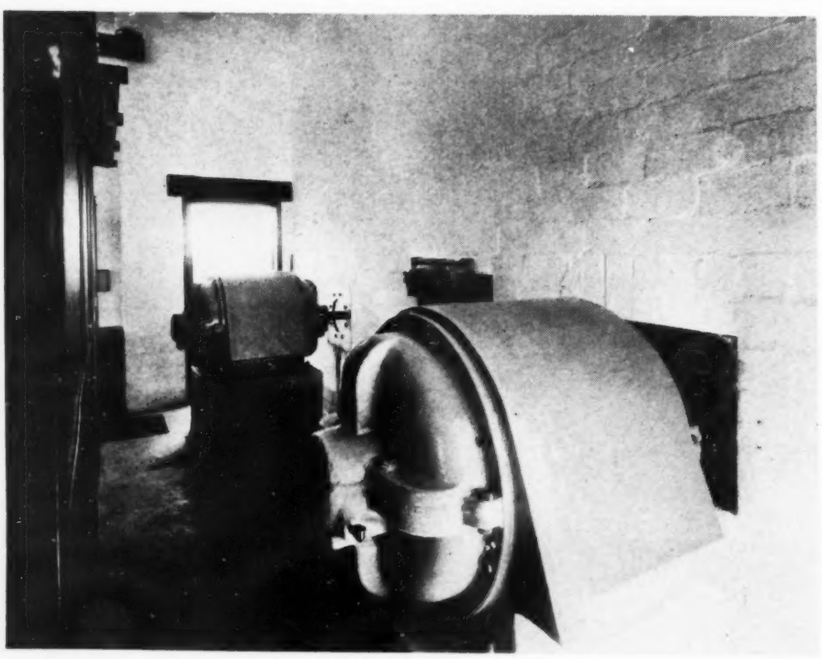


Fig. 6. Unit substation for 2300-volt power supply to an oil pipe-line pumping station or for similar service

Fig. 5. Squirrel-cage induction motors coupled through a fire wall to centrifugal pipe-line pumps



Power Measurement

Only a few electrical instruments are essential in a pipe-line pumping station, though others may be added as desired. A watthour meter on the incoming line is usually supplied as a check on the meter installed by the power company. A voltmeter is also an advantage in determining whether the power lines are energized and the voltage is normal.

An ammeter should be installed for each main pump motor, where it will indicate the amount of load on the pump. Some operators may want an incoming-line ammeter also, but this would be optional.

The only other instruments that might be needed would be for the d-c. field circuits of synchronous-motor drives.

Conclusion

Two major steps should be taken in coördinating electric equipment for centrifugal pipe-line pumps: First, obtain the torque-speed curve for each pump with discharge valve closed, for comparison with the torque of the proposed motor; second, obtain for each station the characteristics of the electric power supply. With this information, the electrical manufacturer can determine the best method of starting and then apply the electric drive successfully. Although thought must be given to the interrelated problems of interrupting capacity, voltage drop, accelerating torque and motor-starting methods, and their influence on the choice of electric equipment, completely successful operation is readily accomplished by an intelligent selection and coördination of standard apparatus.

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Toronto Pipe Line Company	29	Illinois, Indiana	Sheehan Pipe Line Construction Co.
Stanolind Pipe Line Company	75	Oklahoma, Texas	B & M Construction Corporation
Stanolind Pipe Line Company	72	Illinois, Missouri	Oil States Construction Co.
Stanolind Pipe Line Company	180	Illinois, Indiana	Sheehan Pipe Line Construction Co.
Stanolind Pipe Line Company	28	Kansas	O. E. Dempsey Construction Company
Sinclair Pipe Line Company	28	Illinois	Sheehan Pipe Line Construction Co.
Pure Oil Company	7	Illinois	Direct with Owner
Buckeye Pipe Line Company	22	Ohio	Sheehan Pipe Line Construction Co.
Illinois Pipe Line Company	136	Illinois	Sheehan Pipe Line Construction Co.
Natural Gas Pipe Line Co. of America	233	Texas, Kansas, Iowa	W. A. Bechtel Company
Natural Gas Pipe Line Co. of America	101	Iowa, Nebraska	O. E. Dempsey Construction Company
Southern Natural Gas Company	240	Louisiana, Mississippi, Alabama	B & M Construction Corporation
Southern Natural Gas Company	5	Louisiana	Ford, Bacon & Davis Construction Corp.
Southern Natural Gas Company	32	Mississippi	I. C. Little
National Refining Company	8	Kansas	F. A. Erard
Rock Island Refining Company	22	Indiana	Sheehan Pipe Line Construction Co.
Gulf Refining Company	70	Missouri	B & M Construction Corporation
Plantation Pipe Line Company	105	Louisiana, Mississippi	Latex Construction Company
Hope Natural Gas Company	45	West Virginia	Direct with Owner
Standard Oil of Ohio	10	Illinois	Sheehan Pipe Line Construction Co.
American Rolling Mill Company	9	Ohio	Direct with Owner
Frontier Fuel Oil Corporation & New York Transit Company	21	New York	Sheehan Pipe Line Construction Co.
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by

C. M. Taylor

Vice-President,
The Lincoln Electric Company

War Requirements Bring Changes in Arc-Welding Technique

☆ Authorities express views on changes and trends in arc-welding technique as applied to pipe-line construction, a vital activity of paramount national importance

PRESSURE of the war effort and an increased demand for oil pipe lines has brought changed techniques in the welding of the miles of pipes that twist over the nation's hills and valleys, a survey of western pipe-line experts reveals.

The use of "chill rings" to back-up the welds has practically disappeared, according to a recent survey.

"Chill rings now are almost unknown regardless of the size of pipe," said R. L. Townsend of the Phillips and Easton Supply Company, Wichita, Kansas. "They cost more money on installation, collect foreign matter, and slow the flow of liquid or gas after installation."

Townsend's opinions were substantiated by Guy S. Connors, vice-president of Williams Brothers Corporation, Tulsa, Oklahoma, and Harold C. Price, president of H. C. Price Company, Bartlesville, Oklahoma. These concerns are prominent throughout the western hemisphere in the laying of arc-welded pipe lines. H. C. Price Company has laid hundreds of miles of pipe lines without chill rings and Williams Brothers Corporation also has laid many miles of welded line without the rings, notably 600 miles of the Plantation Pipe Line Company's line, 450 miles of the Southeastern Pipe Line Company's line, and 140 miles of the Portland to Montreal line. This latter line included two lines under the St. Lawrence River at Montreal, Quebec. The river at that point is two miles wide and the lines were laid 46 ft. below mean low water, or 16 ft. below the river bottom.

Connors, summarizing progress made in the application of arc-welding to pipe-line construction, pointed out that changes in arc-welding have come as more people became familiar with the technique.

"Gas welding in 1915 was not good, but as more welders became proficient in the art, the technique improved, until in the late 20's gas welding was considered standard practice and the proper method of joining pipe.

"This eliminated screw pipe to a large extent, which was standard practice until gas welding supplanted it.

C. M. TAYLOR

graduated from Western Reserve University in June, 1916—Went to work for The Lincoln Electric Company immediately following graduation and remained until the summer of 1917, when he entered the Air Corps Service—Returned from government service in January, 1919—His first position was as clerk in the production department, then time study department, assistant superintendent, superintendent, and in 1928 vice-president in charge of sales—Serves on the board of directors of The Lincoln Electric Company.

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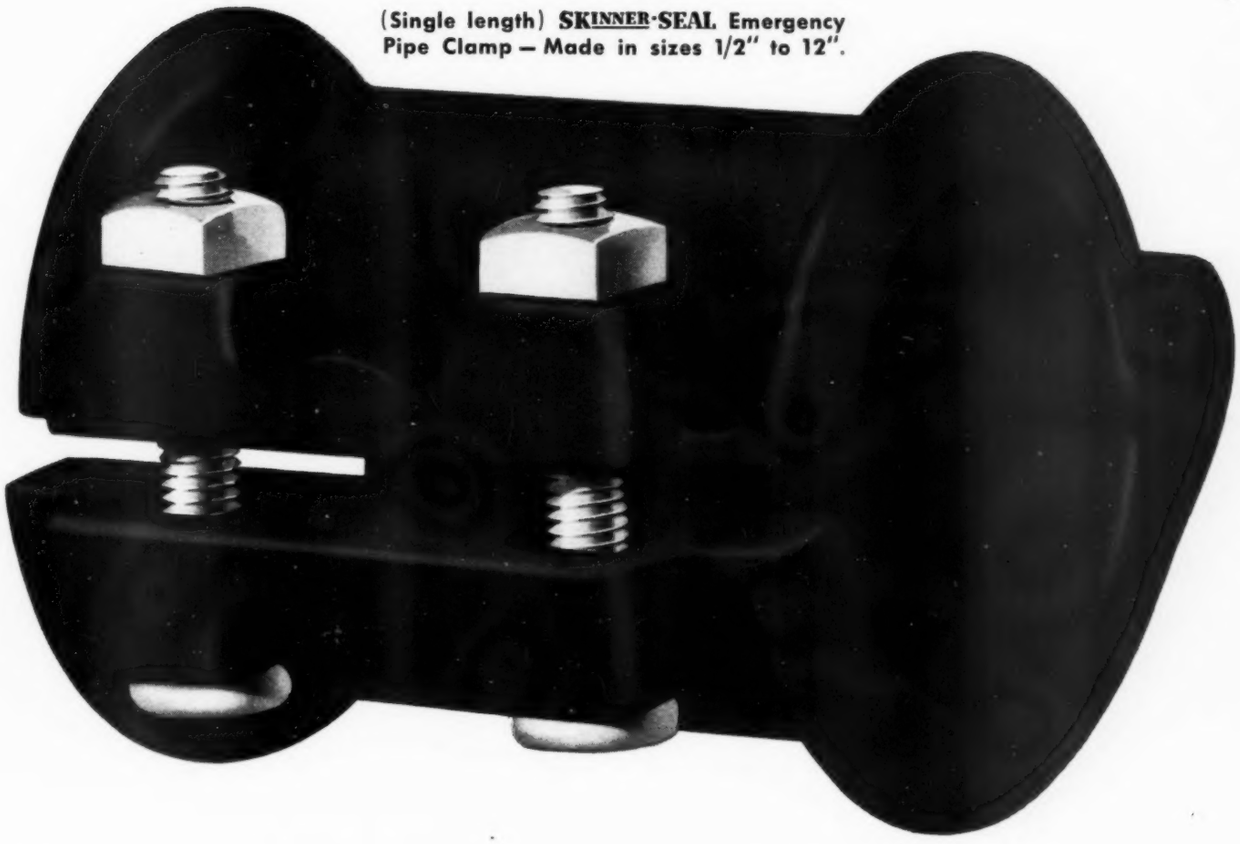

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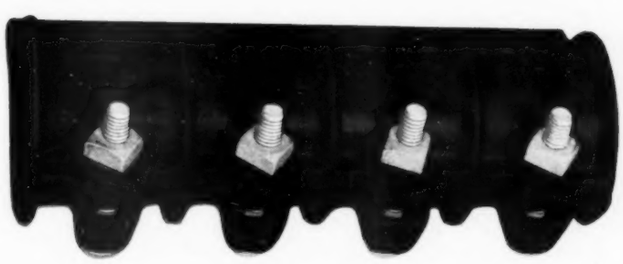

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Top—Alignment fixture holds ends while stringer bead is begun for a welded joint. Bottom—Welders working on section of new Portland-Montreal pipe line

Arc-welding in turn is now the principal method used in joining pipe."

Connors named the development of the coated electrode and the "good salesmanship" of H. C. Price as two factors that contributed greatly to the acceptance of the electric arc by pipeline contractors.

"Price's persistence prevailed and a few companies tried out the 'new fangled' method," he said. "This was 15 years ago. Arc-welding now is almost universally used on main line work by most of the companies as well as contractors.

"As welders increased in number and proficiency and the coated rod was improved, a definite technique was set-up, different size rod being used for the several sizes of pipe and to fit the amperage of the machines. Now, a weld isn't good unless it tests as good or better than the pipe itself. Leaks are seldom found in arc-welded lines today. This is due, no doubt, to the fact that several beads around the pipe are necessary to complete one weld. Each bead in effect anneals the preceding one as well as closing any pin holes."

"There has been a decided trend to welding all sizes of pipe without a backing-up ring," Price said. "This method was developed by our company in the last half of 1939 and during 1940, when we welded a 16-in. line in Venezuela and 18-in. and 24-in. lines in this country without the use of chill rings. We now are welding 26-in. pipe without backing-up rings."

The chief reason that the chill ring has virtually been eliminated is economy. The double-bell connection with a backing-up ring was more costly because the pipe ends had to be belled and because backing-up rings cost 25 to 35 cents each. Double belling costs about $1.50 per ton of pipe, so the expense is considerable, inasmuch as a 40-ft. section of pipe on the average weighs about a ton.

Because the pipes are butted closer together when no ring is used, less electrode is required. (See Table 1.)

TABLE I

Amount of rod used to weld various size pipe

(Less without ring due to close spacing. Thickness of pipe, 1/4 in. to 5/16 in.)

Size pipe, in.	Lb. rod per weld	
	With ring	Without ring
6	1.00	.75
8	1.50	1.00
10	2.00	1.25
12	2.25	1.50
14	2.50	1.75
16	2.75	2.00
18	3.00	2.25
20	3.25	2.50
22	3.50	2.75
24	3.75	3.00
26	4.00	3.25

Most welding and pipe-line experts questioned during the Lincoln survey agreed that stove-piping — welding around each joint individually and in position—was gaining favor over roll, or "firing line", welding, done by a crew of welders as a helper revolves a relatively long section of pipe on a dolly.

"It is almost common practice to stove-pipe a job regardless of the size of pipe; that is, up to where the pipe can be handled with a side-boom tractor," Townsend said. "In the Kansas area, 24-in. and 26-in. pipe is now being stove-piped."

C. K. Rickel of the Big Three Welding Equipment Company, Fort Worth, Texas, agreed with Townsend.

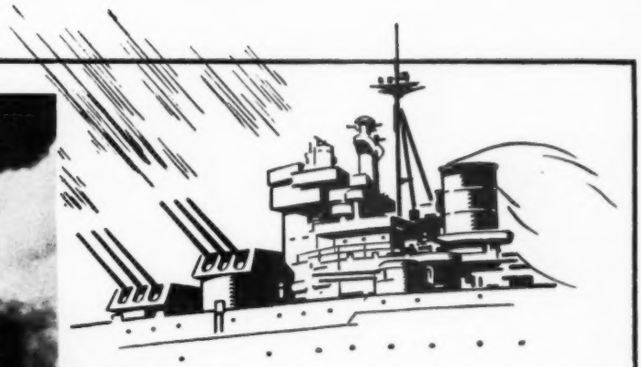
"Pipe-line procedure has changed recently to the point where very little so-called roll welding is done today on pipe lines," he said. "The only place that I know of where they use the roll weld application is on large-diameter gas lines of 18-in. pipe and larger. Practically all oil and gasoline lines, and all gas lines 14-in. and smaller today are put in by the stove-pipe method, which is very simple."

Price, however, favored both kinds, saying that each has advantages in certain applications.

"It is true that some contractors are stove-piping all sizes of pipe regardless of diameter, even up to 26-in., but the economy of this method is a matter of

THIS IS NO TIME

to shoot blanks!



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Construction scene on defense pipe line from Portland to Montreal

opinion," he said. "Most of the contractors who are using the stove-pipe method are doing so because they do not have the larger equipment, including the large welding machines. I am of the definite opinion that there are places for both kinds of welding.

"There is more reason for stove-piping on small-diameter pipe, and less reason for it on large-diameter pipe. Much greater progress can be made per day by roll welding large-diameter pipe."

Accompanying illustrations show lines recently completed by the stove-pipe method.

Price's concern also welded a 26-in. gas line for the Natural Gas Pipeline Company of America in Iowa and Nebraska. This line had a total length of 310 miles.

The pipe, of high-tensile steel, had a wall thickness of only ¼-in. All joints were welded with Lincoln "Shield-Arc 85" electrodes, manufactured particularly for welding high-tensile steel in all positions.

The joints in this pipe were welded in three beads using 5/32-in., 3/16-in., and ¼-in. electrodes. The current ranges for each size were 100 to 160 amp., 125 to 180 amp., and 190 to 325 amp., respectively.

On this line factory bends were used instead of bending the pipe in the field. It was reported that this departure greatly increased the speed of construction. Special ground cables also were introduced. These were used to eliminate any possibility of sparking against the steel of the pipe.

A table of electrode sizes is given in Table 2, as compiled by H. C. Price Company.

TABLE 2

Electrode sizes—Roll welding without backing-up ring

Size pipe, in.	Stringer bead, in.	Second bead, in.	Third bead, in.
4	5/32	3/16	3/16
6	5/32	3/16	1/4
8	5/32 or 3/16	3/16 or 1/4	1/4
10	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16
12	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16
14	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16
16	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16
18	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16
20	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16
22	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16
24	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16
26	5/32 or 3/16	3/16 or 1/4	1/4 or 5/16

Rickel stated that many of the pipe lines being laid now and to be laid in the future during the emergency will be pipe taken up from old lines, reconditioned, torch cut to the proper bevel, and relaid.

"This is due to the acute shortage of pipe in the country today," he said. "Re-use of old pipe is almost entirely a stove-pipe operation and owing to the feather edge due to the torch cut, the pipes are used pretty well butted together without any appreciable spacing left, and ⅛-in. electrode is being used quite extensively for the first bead, which is nothing more or less than a 360 deg. tack."

Townsend pointed out that the degree bevel on pipe has been changed somewhat for arc-welding when thin-wall, high-tensile pipe is used. He added that this also changes the spacing set-up.

Price supported Townsend on the angle change.

"We now recommend a bevel of 25 deg. (50 deg. inclusive angle), for pipe of more than ¼-in. wall thickness," he said. "With pipe ¼-in. or less it will make very little difference whether the bevel is 25 deg. or 30 deg."

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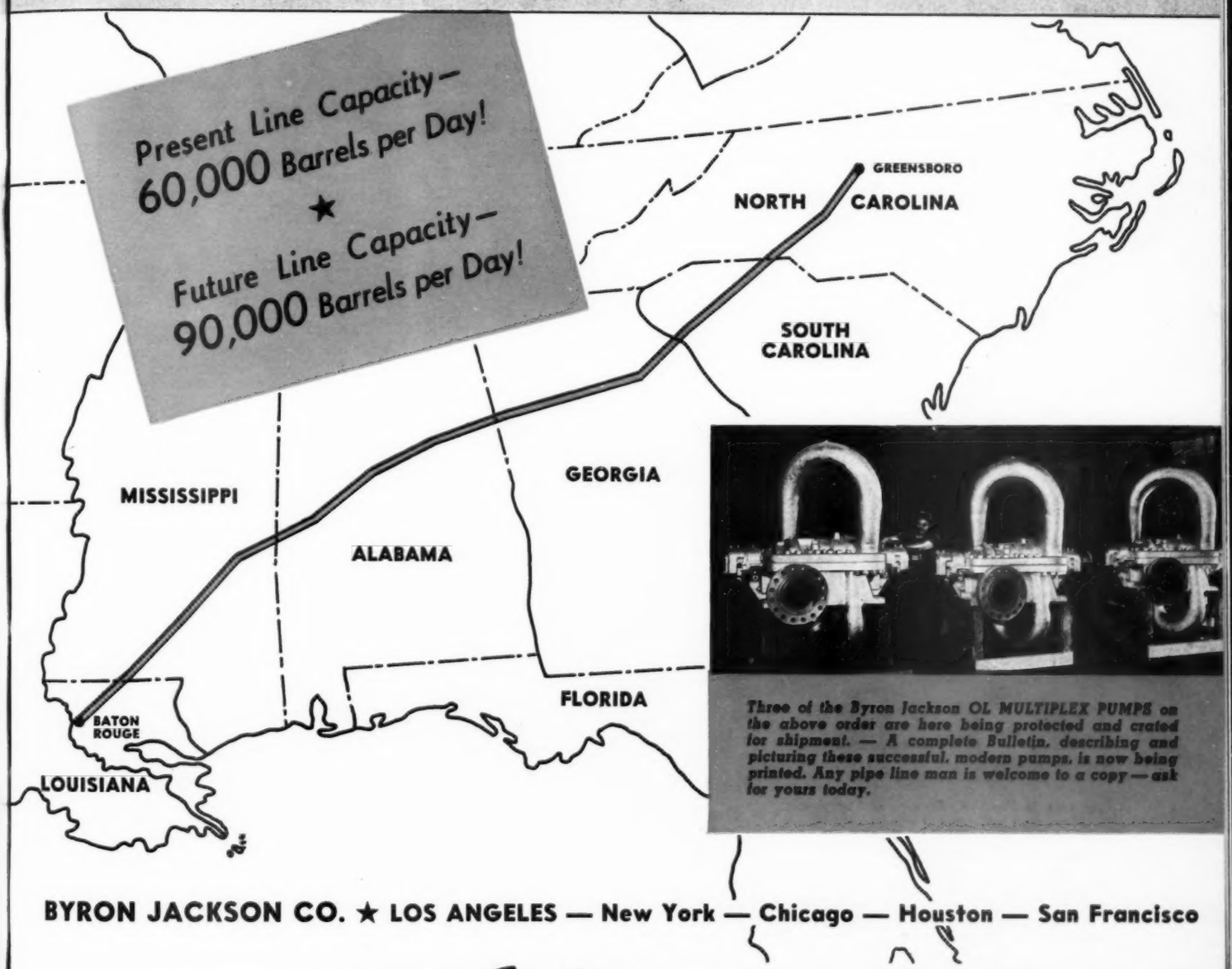

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P 615.
P 590.6

Oxy-Acetylene Flame-Priming of Line Pipe

☆ **Although application of process is relatively new, it may result in better protection against corrosion—Other oxy-acetylene applications to pipe-line work discussed**

by F. C. Hutchison

Engineer, The Linde Air Products Company

THE oxy-acetylene process has an important and varied application in the field of pipe-line work. Oxy-acetylene equipment, which is readily portable, provides a means of welding pipe, making wrinkle-bends in pipe, cutting and beveling the ends of reclaimed pipe, repairing damaged equipment quickly and efficiently in the field, and—although still in an introductory stage — the flame-priming of pipe before coating and wrapping. This last process is of particular interest because of its newness and the advantages it may well offer for giving pipe a more lasting protection against corrosive attack, particularly reclaimed pipe or new pipe intended for soils where corrosion is severe.

Oxy-Acetylene Flame-Priming

Flame-priming has been used on a large scale for similar work in other fields, including the preparation for painting of all types of structural steelwork, ship hull and deck plates, storage tanks, penstocks, dams, locks, and piling. More than 20,000,000 sq. ft. of such steel surfaces are being flame-primed monthly. The U. S. Navy Bureau of Yards and Docks requires that underground pipe lines and storage tanks installed under its jurisdiction be flame-primed before coating.

Flame-priming employs the intense, quick heat of oxy-acetylene flames to expand loose scale and rust encrustations on steel surfaces, causing them to pop-off the relatively unaffected metal underneath, and to drive out the surface moisture. This treatment leaves the surface clean, dry, and warm, making the protective coating go on faster and smoother, bond tighter, and last longer.

The flame-priming operator uses a regular heavy-duty welding blowpipe with an extension arm and a flame-priming head that has a number of closely spaced flame openings providing a series of high-velocity, high-temperature flames. Hard-faced skids on either end of the head keep it the correct distance from the surface of the steel and protect it from abrasive wear. Any scale that remains tightly adherent after the flames have been passed over the surface and the surface has been brushed is judged not harmful to subsequent coating.

Consumption of oxygen and acetylene in this process is low. Because it is designed to produce high-temperature, high-velocity flames, a 6-in. flame-priming head, for example, can be used to treat from 500 to 1000 sq. ft. of steel surfaces per hour.

Pipe Welding

During the last few years, progress in the oxy-acetylene welding of pipe lines can be attributed largely to the improved technique of welding with multi-flame heads by the Lindeweld method. This welding method employs an oxy-acetylene flame with an excess of acetylene, and welds are made backhand with the welding flame pointing backward toward the completed portion of the weld. The speed and economy of this welding method are due to the fact that the surface of the base metal, as it reaches white heat, absorbs carbon from the excess-acetylene flame, in this way lowering the melting point of the steel and increasing the speed of welding. This speed is further increased by use of multi-flame heads, as they provide preheat flames that quickly bring the carburized metal to the "wetting" condition in advance of the welding flames, and also preheat the welding rod.

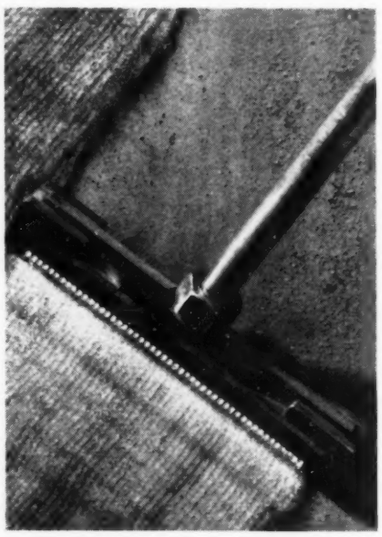
A low-alloy, high-strength welding rod especially developed for this welding method is used. This rod develops an average weld strength 10,000 to 12,000 lb. per sq. in. greater than earlier rods, yet has sufficient ductility to meet any requirements.

Compared with single-flame oxy-acetylene welding, the Lindeweld method results in remarkable savings in welding time—50 to 75 percent for rolling welds and from 30 to 65 percent for position welds. Considerable economies also are realized in the consumption of gases and welding rod.

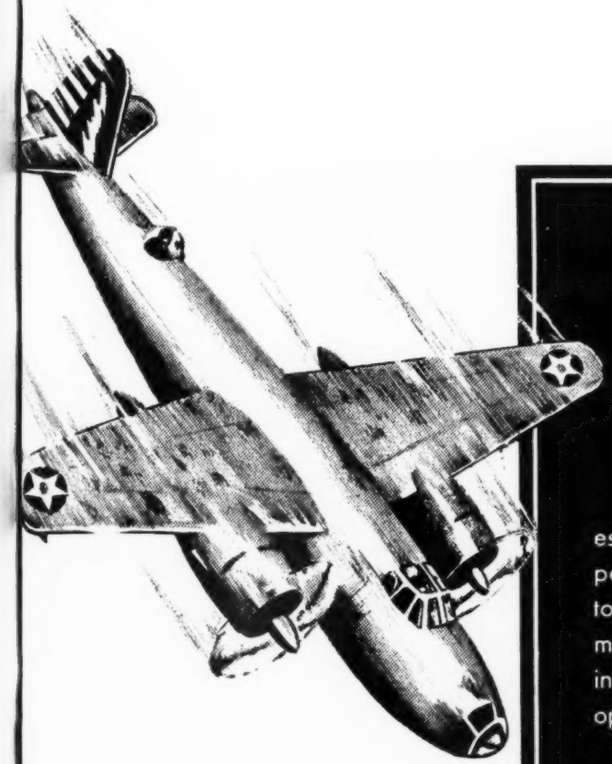
The same welding technique also is

F. C. HUTCHISON

was born in Montreal, Canada, and received his elementary education in Minneapolis, Minnesota—After several years' experience in the manufacture of radio specialties, he entered Massachusetts Institute of Technology to specialize in machine design—Graduated in 1927 with the degree of bachelor of science in mechanical engineering—After graduation he was employed by The Linde Air Products Company —Spent two years in fundamental research work and then was transferred to the Apparatus Development Section—Since 1932 he has served as engineer in process service work—Lives in Kansas City, Missouri.



Oxy-acetylene flame-priming equipment



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Wrinkle bends are made by heating a band halfway around the pipe with a heavy-duty welding blowpipe and then bending the pipe

being used effectively for welding well casing. Two operators using multi-flame heads can complete welds in from 1½ to 4 min. on casing ranging from 5 to 10¾ in. in diameter. In the welding of deep-well casing, this increased speed is of particular importance, as a delay in the setting of the casing may cause the drill hole to become clogged.

Welding operators making rolling welds in pipe, using 6-flame welding heads. Four flames preheat the vee, one flame preheats the welding rod, and a sixth flame does the actual welding

Wrinkle-Bending

Uneven terrain over which pipe lines must travel or changes in the direction of the pipe present no problem if wrinkle-bending is used. In this operation, large-capacity welding blowpipes are used to heat one or more narrow bands of metal at right angles to the longitudinal axis of the pipe, about halfway around the pipe. The pipe is then pulled by block and tackle or by the leverage action of timbers until a wrinkle is formed in the heated section and the pipe is bent to the desired curvature. A bend of about 5 deg. can be obtained by making one wrinkle-bend, and sharper bends are made by increasing the number of wrinkles. Wrinkle-bending causes no reduction in the thickness of the pipe wall and does not decrease the size of the inside diameter of the pipe, so there is no impeded flow or turbulence and no obstruction to scrapers used in cleaning pipe.

Oxy-Acetylene Cutting of Pipe

In the hands of the oxy-acetylene cutting operator, the cutting blowpipe is a versatile tool for many pipe-line applications, including such work as the beveling of pipe ends in preparation for welding. The speed of this method of preparation is particularly valuable for the reclamation of used pipe, where each section of pipe must be beveled at both ends before welding. Special fittings, plugs, and headers, as well as "half soles" used in pipe-line repairs, also can be fabricated quickly and conveniently by oxy-acetylene cutting.

Maintenance and Repair

On every pipe-line project there is inevitable breakage and wear of equipment parts that can be restored economically by oxy-acetylene welding and cutting. As a repair method the oxy-acetylene process is fast and dependable, and often averts a long wait for replacement parts.

By means of bronze-welding, broken castings can be repaired at the scene of the breakdown. Worn surfaces of such parts as ditcher teeth, tractor treads, pins and links, which are subject to constant abrasion, can be built-up with bronze, steel, or various hard-facing materials. When replacement parts of a relatively simple design are needed for ditchers, tractors, and similar construction equipment, often they can be fabricated from steel plate by cutting them to shape and welding them into an assembly.

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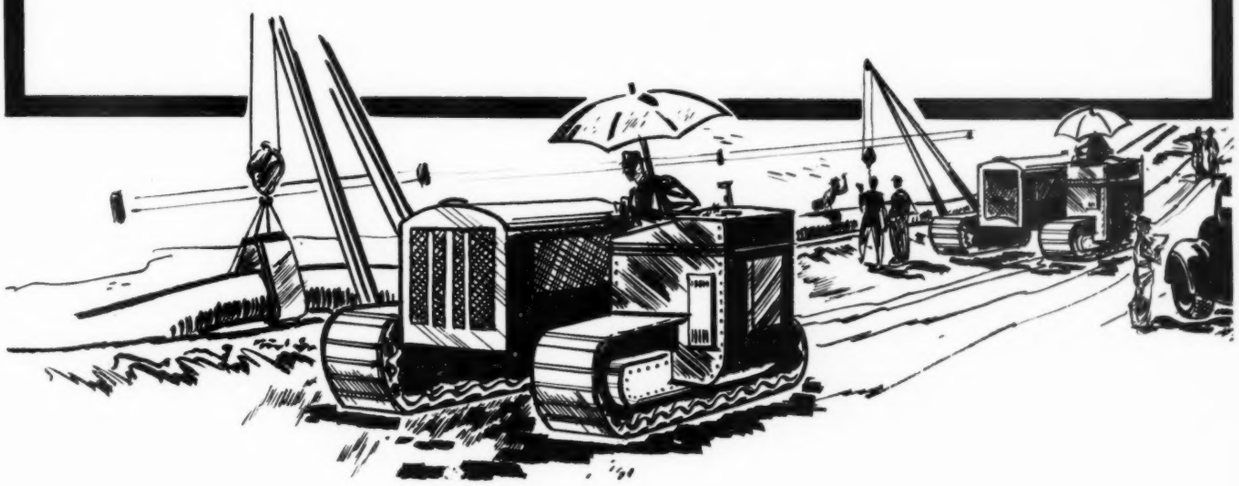

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Fig. 1. An attractive station on Continental Pipe Line Company's system in South Texas

Pipe Lines—Their Construction and Operation

☆ Pipe lines play an important role in national economy—Development and operation of the Diesel-powered pipe-line station

PART I

by G. A. Palmer, Formerly District Manager, Baldwin De La Vergne Sales Corporation

THREE and one-half million barrels of crude oil are produced in the United States every day, in widely scattered regions determined by nature millions of years ago, without any regard to their accessibility by mankind, or geographical relationship to the market for these products. The ways and means of gathering up this vast amount of crude oil at the producing wells and moving it to distant refineries, generally located at seaboard or in highly populated regions, are indeed peculiar to the petroleum industry by which they were developed during 80 years of existence. The system consists of a vast and intricate network of underground pipe lines with pumping stations that originate atop the Rocky mountains in Utah and Wyoming, in the region of the Carlsbad Cavern in New Mexico, from within a stone's throw of old Mexico on the banks of the lower Rio Grande, and from almost all parts of Texas. From these regions the lines spread eastward and northward to the Great Lakes area and still farther eastward to the Atlantic seaboard. Another similar network covers the California area.

G. A. PALMER

To those who knew "Gap" Palmer this article will be of particular interest—It was written just a few days before his death in Houston, Texas—During his quarter century of service in the petroleum industry he earned the respect and admiration, not only of his De La Vergne associates, but of many of the pioneers and leaders who built and operate the nation's great network of pipe lines—He contributed much to the development of Diesel engines for pipeline pumping service and earned an enviable reputation for his integrity and loyalty—It is a record of which his family and friends may well be proud.

Oil Lines Extend 100,000 Miles

These networks comprise more than 100,000 miles of continuous lines of sizeable pipe, with many more thousands of miles of smaller lines. Like the nation's railroads, management and ownership are made up of several score of operating systems, each complete with its own main line, field and gathering lines, and operating organization, and each owned and operated by a competing major company. Also involved are a great many similar but less extensive systems with smaller groups or individual ownership and, with operations generally confined to smaller areas.

Lines operating in two or more states are designated by the government as common carriers and, like the railroads, they are under the jurisdiction of the Interstate Commerce Commission. Like our railroads, these pipe lines transport a commodity from any shipper to any consignee. In contrast to railroad operations, however, the only commodities handled are petroleum products, generally crude oil, and nothing but the commodity itself is transported, as no vehicles are involved, and the traffic

is always limited to one direction. Moreover, the pipe line or "track" is filled with a continuous stream of oil, which would be comparable to railroad operation with a train of unending length, and the movement seldom ceases.

The cost of a pipe-line system per mile of length approaches that of a railroad, but when the natural conditions of supply in one region and the market demand in another may be considered sufficiently stabilized to insure a reasonably long term of usefulness, the economics of the oil pipe-line transportation system show a lower cost per ton mile of movement than the corresponding costs of transportation in tank cars. The hazard of loss of commodity in transit and of damage to property are considerably less in pipe-line transportation. These many reasons probably explain why 90 percent of the total production of crude oil is handled in pipe-line systems.

Although a great many of the pipeline transportation systems are owned and operated by companies engaged in producing, refining, and marketing of petroleum and its products, and although only the stabilized transportation demand of such large integrated oil companies could justify economically the construction of major oil pipe-line systems, these systems as common carriers meet the general demand of the nation in its free economic development of the petroleum industry by providing a ready market to the innumerable small independent producers, and by making it possible to meet the refiners' unending demand for raw products.

Cuts Petroleum Products' Cost

Without this efficient and economical system of specialized transportation for the petroleum industry, the cost of petroleum products undoubtedly would never have reached its present low level, and as a result thereof the industry could not have developed to its present magnitude. Such retardation of the industry in turn would seriously have held back the development of the automotive industry and its influence on our national economy. The low cost of gasoline, notwithstanding its heavy tax burden, has for example, contributed largely to the popularization of the automobile as a means of transportation. Thus our country has been more closely knit together by interstate commerce and travel.

Only the availability of a good low-cost fuel oil has made possible the widespread use of the oil-fired household heating unit. This, again, has meant new industries—increased employment.

Oil from the innumerable wells is started on its journey by first being delivered into the producers' lease tanks. This movement is accomplished by the natural pressure of the well itself, or that of the well-pumping unit. The pipe-line company takes delivery of the oil from this lease tank upon gauging and sampling it to determine the quality and quantity of the oil, and issuing a receipt therefor. The oil is flowed by gravity or by means of suction pumps through the company's system of small gathering lines—connecting also to lease tanks of other producers in the immediate vicinity—to tanks at a central or field station. From such field stations the oil is pumped through large lines to the initial terminal or to an intermediate station of the operating company's main pipe-line system, before beginning its final movement to the refinery terminal that perhaps is several hundred or a thousand miles away.

The main or trunk pipe-line system may consist of one or more continuous pipe lines from the initial terminal to its distant refinery or seaboard destination. Sizes of the lines may be anywhere from 8 in. to 16 in. in diameter, depending upon the quantities of oil to be handled, the gravity or viscosity.

Fig. 2. Backfilling the ditch after the pipe has been lowered-in

Fig. 3. Trench is dug at high speed with modern equipment of this type

and other factors. The lines are buried from 14 to 18 in. deep in a straight ditch, but in laying the line it is waved back and forth against the sides of the ditch to provide for reaction to temperature changes and thus insure against line breaks

A Pumping Station Every 40 Miles

Pumping stations are required at the initial terminal and at suitable intermediate distances, their locations generally being from 30 to 40 miles apart, depending upon the hydraulics of the line and its topography. Barring natural difficulties, a generally straight course for such a line is selected, though passage through cities or heavily populated districts generally is avoided for obvious reasons. Thus these lines may traverse rugged mountainous regions with pumping stations situated at a considerable distance from towns or railroads, or in turn they may pass under the fertile wheat fields of the prairies of our central west.

Operating or line pressures at the pumping stations in general are from 700 to 1000 lb. per sq. in., and pumps used are either of the positive displacement plunger type, or centrifugals of the multi-stage type. This high initial working pressure, of course, is dissipated as the succeeding pumping station is approached. The plunger-type pump, of course, is more efficient than the centrifugal, particularly when a heavy or viscous oil is involved. The centrifugal pump, on the other hand, involves a much lower investment, both in the pump itself and in its installation. This is an important factor influencing the selection, particularly for installations that may not be of a permanent nature. The pumps frequently are driven by electric motors when dependable electric energy is available at low cost from nearby transmission lines and when the economics of operating otherwise indicate a lower operating cost by use of such electric energy. Many of the pumping stations are situated at a remote distance from available sources of electric energy, however, and as the Diesel engine is a power unit of high efficiency in itself, and one that operates satisfactorily when using a crude oil fuel, Diesel power is commonly used.

Diesel Fuel Supply Assured

Obviously the nature of the situation guarantees an available supply of Diesel fuel so long as operation of the station may be required. Incoming and outgoing lines at a station are connected through a system of manifolds to the suction and discharge of the pumping units and to the station operating tanks. In usual operating practice, the manifold valves are set so that the station operating tank "floats" on the incoming line from which the pumping unit takes its suction, the pumping unit discharging directly into the outgoing line. Thus, with ideal conditions of uniform pumping rates at all stations there is no movement of oil into or out of the operating tanks. This condition is desirable to avoid unnecessary exposure of oil in transport to atmosphere and consequent loss of lighter elements by evaporation. Neither working nor storage tanks have full free opening to atmosphere, but they necessarily "breathe" with daily temperature changes, and thus vapors from actively moving or changing oil are lost. This practice is also desirable to avoid contamination or intermixture of oil in transit with that in the working tank, as different grades of crude oil are kept strictly separate from each other in their movements from field to refinery.

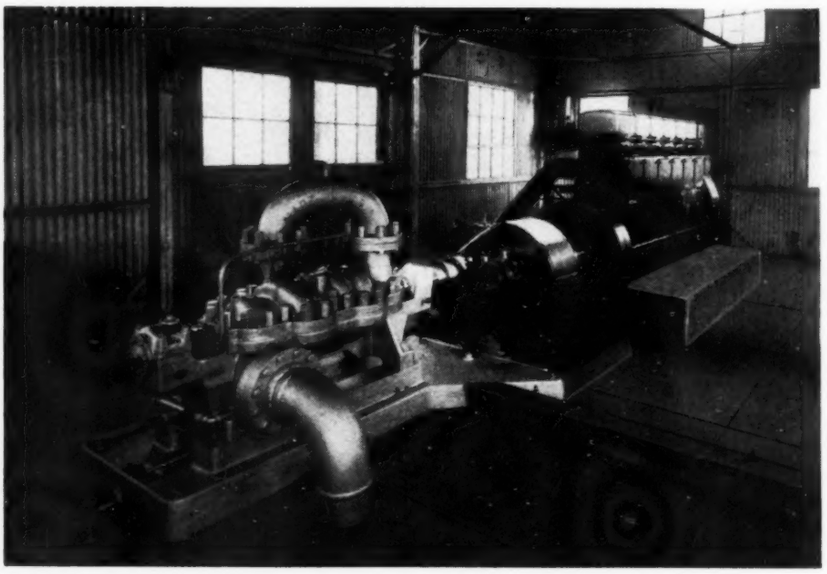


Fig. 4 (right)—A 6-cylinder Diesel engine connected to a centrifugal pump in an Oklahoma station

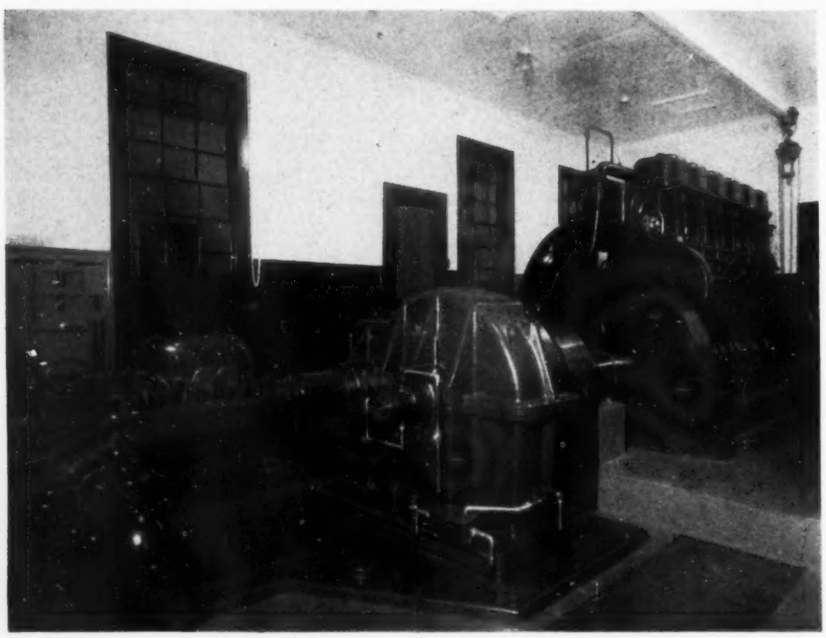


Fig. 5 (below)—Interior of oil pumping station in South Texas

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer.*

P 615.332.

Coating and Wrapping Pipe by Machine

Self-propelled, line-traveling machine is among latest additions to speed-up pipe-line construction

by W. H. T. Thornhill

Vice-President, Wailes Dove-Hermiston Corporation

W. H. T. THORNHILL

attended Pennsylvania State College, and the Towne Scientific School of the University of Pennsylvania, receiving from the latter a B.S. degree in mechanical engineering in 1911—For one year he was a research associate at the University of Pennsylvania—For 11 years was with Midvale Steel Company, Philadelphia, and was Philadelphia district manager for Lancaster Iron Works for two years—Entered employ of Wailes Dove-Hermiston Corporation in 1925 as a salesman, advancing eventually to vice-president in charge of sales, his present position.

DURING recent years there has been a tremendous development of different types of machines for use in constructing pipe lines. Practically every piece of equipment now employed in constructing a modern pipe-line system is mechanized. Anyone visiting a pipe-line construction job for the first time in 5 or 6 years would be amazed at the array of machines now being used. Back-breaking labor so common on early pipe-line jobs is now rare except on emergency jobs requiring handwork. Improved equipment for clearing the right-of-way, modern ditchers, welding machines, cold-bending devices, trucks and "cats" for hauling and handling pipe, cleaning, priming, and coating machines, backfilling equipment, all are employed for greater speed and efficiency in modern pipe-line construction.

One of the latest pieces of equipment is the modern line-traveling coating and wrapping machine. This machine is self-propelled along the pipe and applies the hot coating material, together with a suitable wrapper, mile after mile, uphill and downhill, and around bends, immediately prior to lowering the pipe into the ditch.

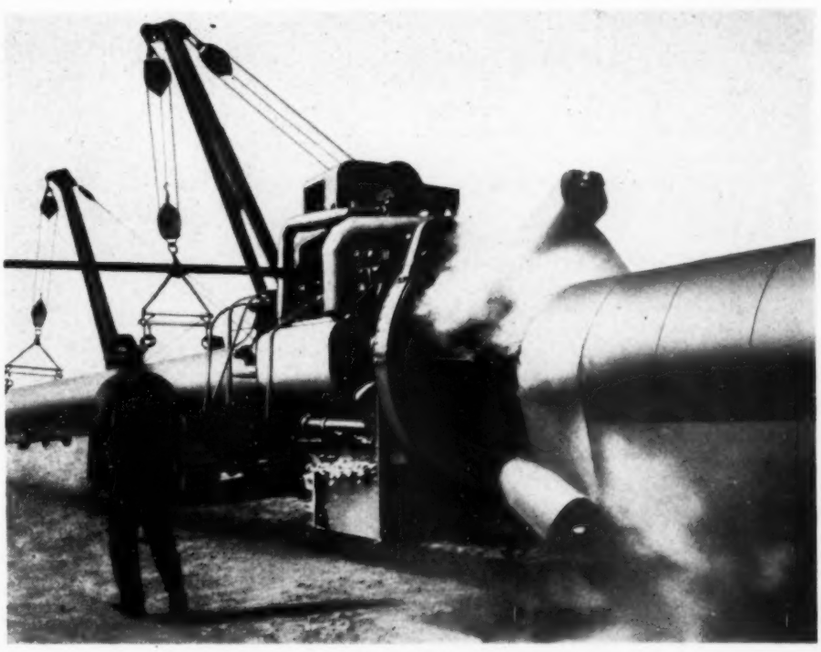
The latest of these line-traveling coating and wrapping machines is that of the Wailes Dove-Hermiston Corporation. It was developed by W. F. Focha, chief engineer of the company. Focha previously had considerable experience with the development of lining and coating machines for water pipe (steel and iron) and with stationary-type machines for the end-feed method of coating pipe used in gas and oil lines. The principal objective in developing this new machine was the application of pipe-line coating at the smallest expense, both to the pipe-line company and to the contractor.

The new machine consists essentially of a sump tank underneath the machine into which hot coating material is pumped from the heating kettle. From the sump tank the hot coating material is pumped into an annular ring that surrounds the pipe and whose inner face is several inches from the outside surface of the pipe.

In the inner face of the annular coating ring there are numerous holes of suitable size and spacing. The hot coating material, under pressure, is ejected through the holes in the inner surface of the ring, flooding all surfaces in a plane at right angles to the center line as the machine moves along the pipe. Excess coating material falls back into the sump. Simultaneously, the coated pipe is wrapped spirally by the wrapping device at the rear of the machine.

A special hot air furnace equipped with a blower is arranged on the side so that the hot air blows around the coating ring, the pump chamber, and any other surfaces that require heat to prevent the enamel from congealing. The various parts of the machine are compactly arranged. One gasoline-driven engine propels the machine along the pipe, and provides power for the pumps and wrapping attachment. The machine has ample power to climb grades, will negotiate bends, and is equipped with a braking device that controls the speed when going downhill.

A uniform thickness of coating material is applied to the pipe and only a minimum amount of coating material is applied for a specified thickness. This is accomplished by flooding the



Coating and wrapping pipe with a line-traveling type machine

entire surface of the pipe with the hot coating material at one time and in the same plane. No coating material is applied to the top of the pipe at one point and the rest at another point. The use of an excess of coating material is thus prevented.

The machine applies a double coating of material to the bottom of the pipe over approximately a third of the bottom surface. Double coating the underside of the pipe is accomplished by pumping the coating material under pressure into a group of separate orifices extending around the bottom-side of the pipe surface for a definite distance on each side of the vertical center line. These supplementary orifices are situated ahead of the main coating ring. This coating application solidifies to such an extent that in reality a double coating is applied to the bottom surfaces when the main coating ring passes them.

Double coating the bottom side of the pipe is extremely important. The full thickness of the double coating compensates for subsequent gradual thinning of the coating by compression from the weight of the pipe and so provides better protection against the action of corrosive waters that accumulate in the bottom of the ditch, which is a veritable drainage canal for the adjacent soil.

The vital parts of the coating machine are maintained at a temperature of approximately 600°F. throughout the work-day by indirect heat provided by the specially designed furnace. This enables the coating material to drain promptly when the machine is stopped. It also permits the machine to start immediately at any time, ready to coat pipe and coat it perfectly.

Stoppages and delays are frequent on any pipe-line job, even under the best operating conditions; these may last an hour or more, and so increase cost. Any reduction in this item of cost is desirable. By maintaining constant heat in the vital parts of the machine, delays in coating operations occasioned by preliminary heating of the machine in restarting are eliminated.

As applied to the pipe by this machine, the coating material is practically free from uncoated areas when starting and from holidays, because the heavy volume of hot coating material flooding the pipe's surface washes-out any holidays that might otherwise form. Virtual elimination of holidays reduces the number of men required for "touching-up" behind the holiday detector, and consequently reduces the contractor's cost for this operation.

No part of the coating machine scrapes or comes in contact with the surface of the pipe after the coating material has been applied. Furthermore, no coke is formed in the machine because, as a common practice, it is unnecessary to use a blow torch to heat the essential parts of the machine. There is no possibility, therefore, of pieces of coke, which come over from the kettle despite screening, or which may be formed by the local heating mentioned, becoming wedged between the coating device and the pipe. Such a defect might not be noticeable immediately and often it would not be noticeable at all, because it would be hidden from sight by the wrapper. The coating on the pipe would then be defective because this coke when dragged along the pipe produces a longitudinal holiday. If this defect were discovered by the holiday detector, repairing it would require considerable extra material and labor. If the defect was not discovered, corrosion of the pipe would occur.

Last year this machine was employed for the coating of approximately 50 miles of 26-in. O.D. steel pipe for the Natural Gas Pipeline Company of America. After the necessary adjustments had been made at the beginning of the work, the machine coated this mileage of pipe without a major breakdown or delay to the contractor.

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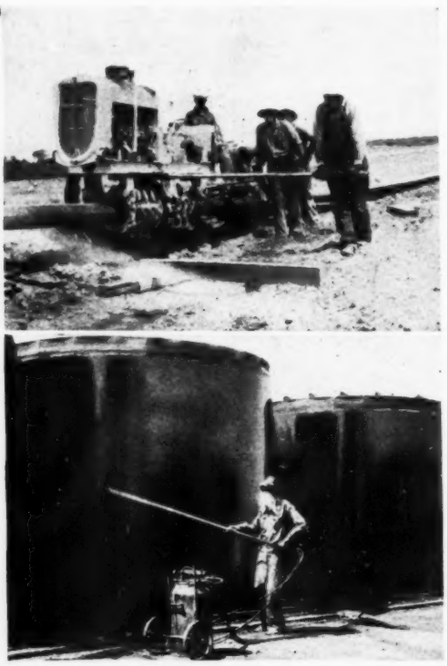

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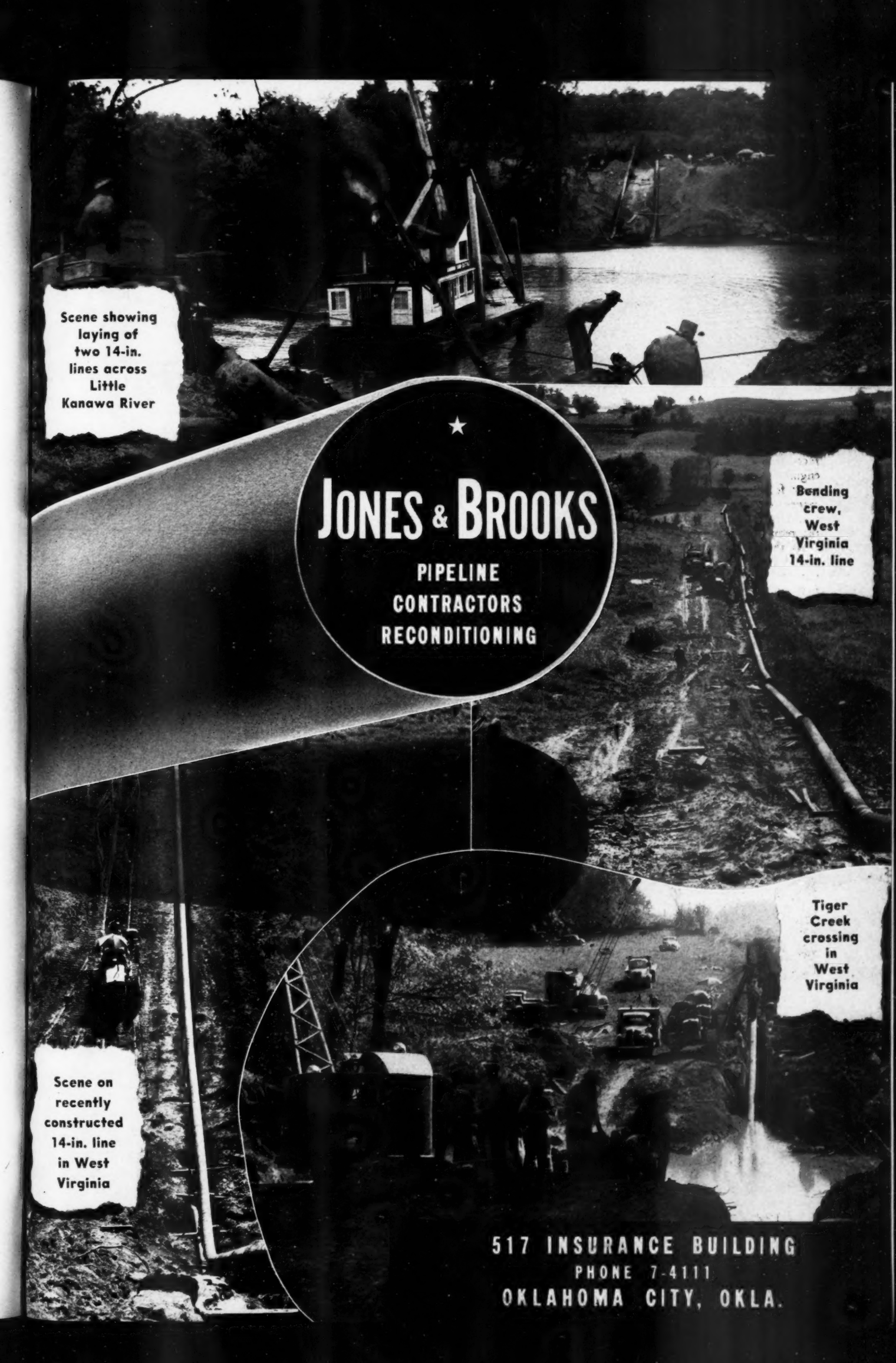
Scene showing laying of two 14-in. lines across Little Kanawa River
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Bending crew, West Virginia 14-in. line
Tiger Creek crossing in West Virginia
Scene on recently constructed 14-in. line in West Virginia
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Unavailable Compressor Parts Fabricated by Pipe-Line Employees

PETROLEUM ENGINEER Exclusive Feature

☆ Distributor heads and collector rings made for magnetos of foreign manufacture

by M. M. Heller

Assistant to the Superintendent, Compressor Stations, United Gas Pipe Line Company

EARLY in 1941 the war in Europe made it impossible to obtain replacement parts for the foreign-manufactured magnetos used on compressor engines. United Gas Pipe Line Company found it desirable to keep these magnetos, having 84 in service, and therefore set out to find a way to make the required major replacement parts.

As the only parts of magnetos that need frequent replacement are the distributor head and the collector rings, first attention was given to those parts. At the Baton Rouge, Louisiana, station, Chief Engineer R. C. Henderson, who has experimented with plastics, volunteered to make the heads. At Latex, Texas, station, W. O. Nowlin, machine shop superintendent, began work on the collector rings.

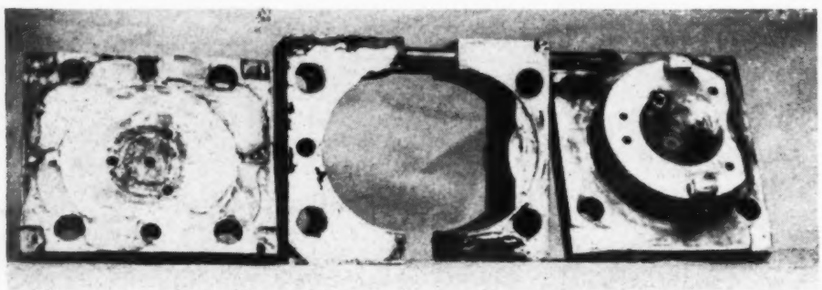
Making the Distributor Head

The magneto is a 6-cylinder type, adapted for 3-cylinder operation and supplying ignition to two plugs in each cylinder. The part was redesigned on paper to eliminate the unnecessary electrodes and to place the high-tension leads in a symmetrical manner.

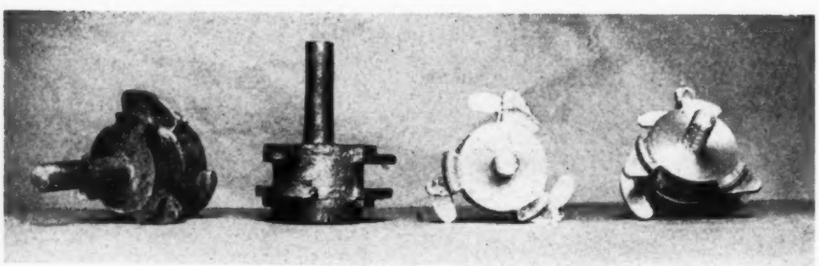
M. M. HELLER

received his degree in mechanical engineering from the University of North Dakota in 1924—Worked for the U. S. Cast Iron Pipe and Foundry Company of Pennsylvania as junior operator engineer—In 1927 he accepted a teaching position at the University of Texas Engineering School where he taught mechanical and electrical engineering until 1937—In 1937 resigned from teaching to become an engineer with United Gas Public Service Company, later merged with United Gas Pipe Line Company—Is now assistant to the superintendent of Compressor Stations of United in Shreveport, Louisiana.

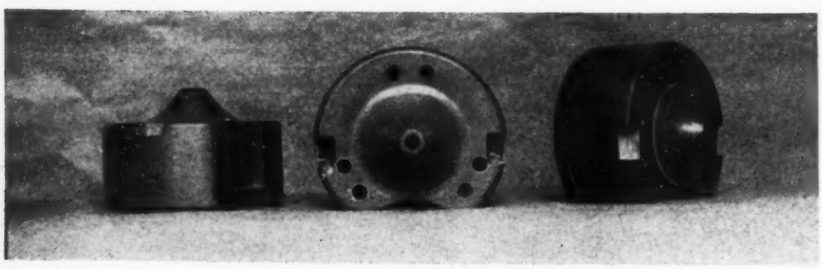
Four-section mold of newly designed magneto part



Two rough and two machined electrode castings



The finished distributor head

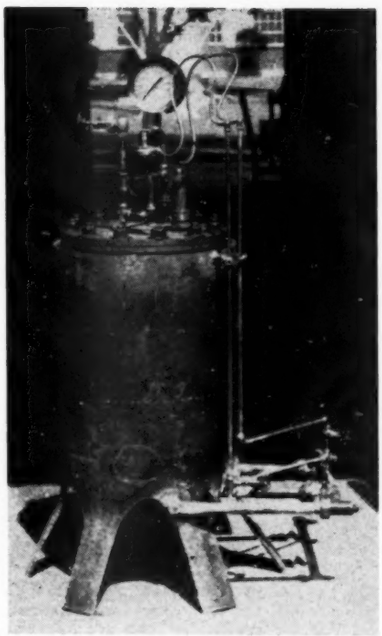


A four-section mold was then built as shown in the accompanying photographs. The mold is bolted together with ¾-in. S.A.E. bolts to provide the required strength.

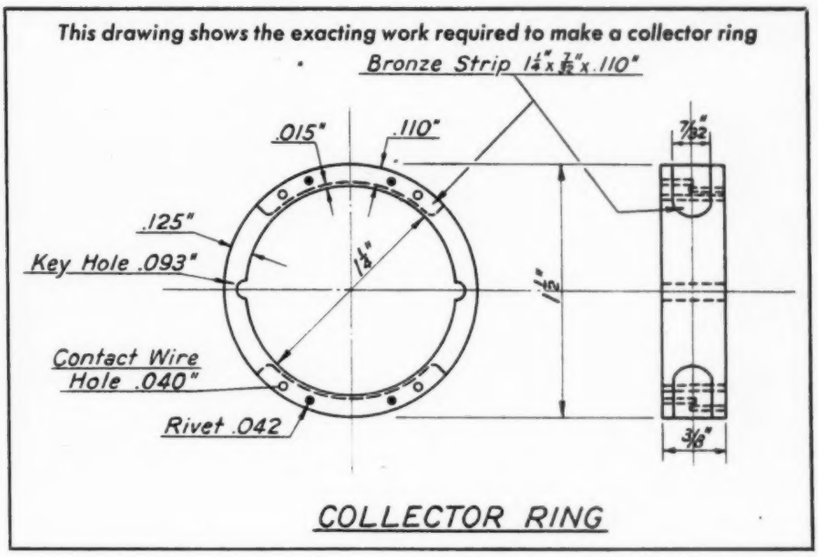
Electrodes that go inside the heads are first cast integrally with the core of the mold, then machined down to the required dimensions after which they are drilled, tapped, and securely fastened in the proper position in the mold. The plastic that is to form the head is packed around the electrodes and core and the flask is then closed under pressure.

For vulcanizing the head, a steam boiler was constructed from a scrap piece of 10-in. pipe, 20 in. long, jacketed by another piece of 18-in. pipe. The burner equipment was salvaged from an old gas cook stove, a relief valve was installed to make the equipment safe, and a pressure gauge and temperature regulator installed to control the vulcanizing conditions.

After the heads are processed in the vulcanizer and have cooled sufficiently,



Vulcanizer used in making distributor head



the mold is removed and the head finished in a lathe. The metal core and the inner surfaces of the head are machined-out, leaving only the contacts firmly imbedded in the plastic.

Rubber was used as the material for the head at first, but the final product frequently was porous and after spoiling a few heads a plastic material (Vinylite, made from natural gas) was found that was more satisfactory, and could be worked in one-third the time of rubber. All Vinylite heads turned out to date are reported to be operating satisfactorily. Approximately 1 lb. 6 oz. of Vinylite is used for each head, which is processed for about one and one-half hours at approximately 300°F.

Making the Collector Rings

To make the collector rings a small bench drill with rigid spindle bearings was used to operate an end mill correctly. A milling jig made of an angle plate was designed and made by Nowlin to aid in accurately cutting out the

SHEEHAN PIPE LINE CONSTRUCTION CO.
JOHN B. SHEEHAN
General-Manager
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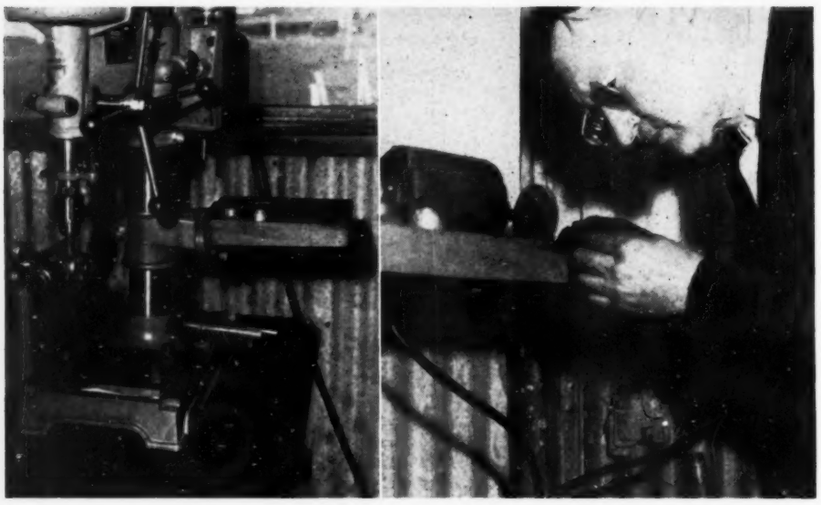

The bench drill with endmill, and milling jig in place (left). W. O. Nowlin (right) touches up a drill

slots in the fiber and to accommodate a collector ring for both right- and left-hand magnetos. The jig permits the milling of slots in both sides of the fiber ring with a 180 deg. turn and has set stops to regulate the length of each slot. Another jig was made to facilitate locating and drilling lead wire connections and dowel pin holes.

In the operation of making the collector ring, a piece of the round fiber 3/8-in. long, 1 5/8 in. O.D., and 1-3/16 in. I.D., is placed in the milling jig and slots are cut in both sides to hold the pieces of bronze that are machined to dimensions of 1¼ in. by 7/32 in. by 0.110 in. deep. At 90 deg. to the slots, half circles are cut in the inside of the fiber ring with an 0.093-in. drill to make key seats for securing the collector rings in the bakelite holder. Strips of the bronze, which are made from a 1¼-in. I.D. by 1½-in. O.D. phosphor bronze tube, are machined to size and glued into these slots in order to hold them in place while holes are drilled through the side of the fiber and bronze rings with an 0.042-in. drill. Rivets made of brass wire of this diameter are then driven through these holes to keep the bronze strips in the slots. Four rivets are used for each slot and are staggered to avoid weakening the fiber.

The last operation is to drill the holes for the contact wire, four holes 0.040-in. in diameter, each correctly aligned to agree with the bakelite holder.

Once the necessary equipment is set up and the rings made, they can be turned out rapidly at low cost.

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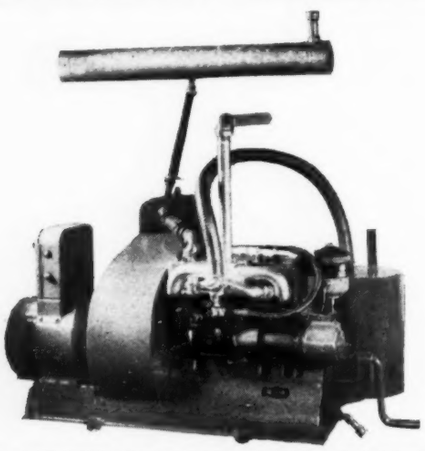

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Handling Line Pipe in the Central Yard

PETROLEUM ENGINEER Exclusive Feature

☆ Imperate need for salvaging steel emphasizes growing importance of pipe reconditioning technique

by Frank H. Love
Managing Editor

COATING and wrapping of line pipe in a central yard is not a new operation. Application of coatings in this manner had its inception a number of years ago largely because field application of coatings left something to be desired, principally that due to natural but unavoidable conditions, such as weather, inadequate facilities, etc., it was found impossible to apply the coating to pipe in a manner to assure maximum protection. There was the further factor of excessive waste of coating material and inadequate inspection due to the range and scope of the field work. Since that time great progress has been made in the equipment used and therefore in the efficiency with which pipe is coated in the field and it is quite true that field application has a definite place on specific jobs. Rapid strides also have been made in the technique and equipment with which pipe is coated in the central yard. Both methods today have their place in the pipe-line industry; one serving better than the other when particular conditions applicable to the explicit merits of each seem best to fit the job at hand.

The present discussion, however, will concern the handling of pipe in the central yard.

Until a few years ago, 8-in. pipe was considered the maximum diameter that could be coated and wrapped successfully in a central plant; now pipe as large as 120-in. in diameter is easily handled. The larger-diameter pipe, of course, is not used in the oil and gas pipe-line industry but it does serve to reveal how versatile central yards have become. This advancement has necessitated careful planning both with respect to methods employed and equipment used.

In the Gulf Coast and Mid-Continent areas is situated one of the pioneers in central plant coating and wrapping of pipe.* Consideration of their methods and plant layout are of value because they exemplify the efficiency and versatility that can be attained in this work.

When pipe-line construction operations are near enough to the main plant at Houston pipe is coated and wrapped there. Otherwise a central yard is set-up close to construction crews and the job just as efficiently performed.

High Percentage Reconditioned

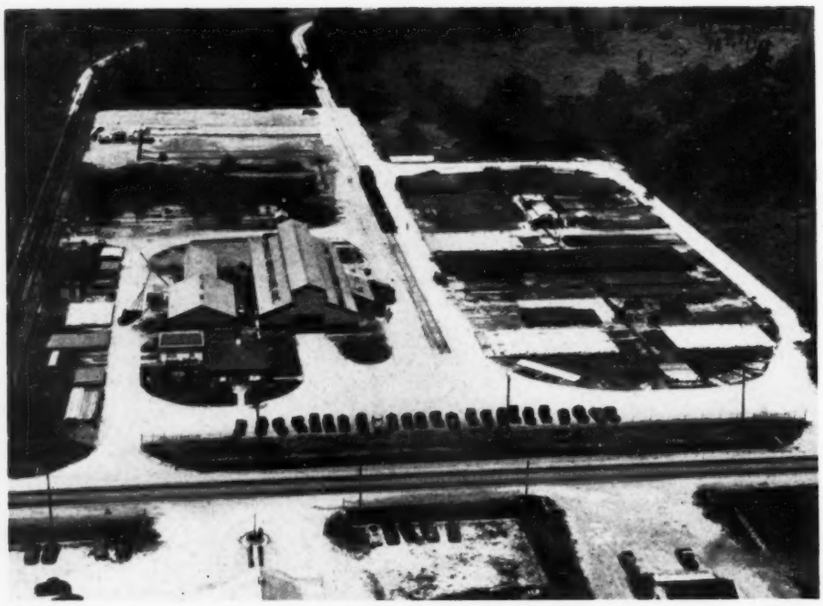
At one time virtually all pipe handled in the central yard was new stock. Within recent months, however, that is, since the United States actively entered upon its armament program and steel became increasingly hard to obtain, a marked change has come about. Increased thought is being given to salvaging every foot of pipe that can be salvaged. Consequently, the central yard is now handling approximately 60 percent old pipe as compared with 40 percent new and has to a great extent becoming a reconditioning yard. This has necessitated the addition of certain equipment for cleaning off old coating, straightening, beveling, testing, and culling, not needed originally.

Today, then, it is observed that the central plant must have enlarged facilities so that new pipe can be coated and wrapped, old pipe reconditioned, and another new factor is the stocking of reconditioned pipe for the customer until such time as he may find use for it. This widening in scope of the central plant's function requires that the yard be considerably larger than formerly, considerably more equipment is needed, and a well-knit and experienced organization familiar with good pipe-line practice is essential.

Procedure

An accompanying illustration shows the layout of the yard under discussion. Actually in use are 8½ acres of a 17-acre plot on which are set-up five complete cleaning, coating, and wrapping units. A 40-car spur has been built into the plant for transportation in and out of pipe. Pipe is unloaded from the railroad cars by heavy-duty gin trucks, the pipe placed on stringers and rolled to the point where it is to be cleaned and coated. As most of the pipe received has originally been laid coated, mostly cold applications or hot bitumens without wrappers, it is necessary to remove this old coating after the crooked joints have been straightened by hydraulic-type straightening equipment. The coating is removed by stationary-type cleaning machines

*Mayes Brothers, Inc., Houston, Texas.



Aerial view of central plant for reconditioning, coating, and wrapping pipe

equipped with patented knives and milling tools that have been "face-hardened." When the condition of the pipe is such that these machines cannot adequately clean-out all pits and corroded areas, sand-blasting equipment is available. The next step after cleaning is to grade the pipe and remove any areas that may be too badly corroded to be of further service. Old "ripple" welds also are cut out and old fittings removed. Normally reclaimed pipe is welded into 40-ft. lengths, as this length pipe is easiest to haul and most convenient to lay. All corroded spots as deep as half the thickness of the pipe wall are spot welded by the electric method. The ends of the joints are beveled with acetylene cutting machines and the pipe is ready for the final operations. The joints are again run through a stationary cleaning machine to which a priming head is attached. The pipe must be allowed to dry after the primer has been applied and before coated in order that a good bond between primer and coating may be obtained. The length of time required for the primer to dry depends to a considerable extent upon weather conditions, usually 2 to 4 hours. The manufacturer's specifications of the particular coating to be applied are rigidly adhered to.

Coating and wrapping is a single and a continuous operation. Accompanying photographs show views of this work. The pipe is placed on back-table rubber rollers, adjustable to fit the size of the pipe. The pipe is moved forward through the coating machine at a uniform speed and in a spiral motion. Each joint of pipe is fastened to the one just ahead by means of a special coupling. The operation is performed while the pipe is in motion thus making a continuous operation and assuring uniformity in the coating and wrapping.

Coating Flooded On

Coating is applied by the flood method. As the pipe passes over a working pot hot coating is flowed over it from hoppers. The number of coats to be applied determines the number of hoppers used. Customary practice is to apply two coats, thus, in this instance, two hoppers would be used. Surplus coating material flows back into the working pot beneath the pipe, is picked-up by a centrifugal pump, and discharged to the header, from which it again enters the hoppers. This operation assures the coating of being stirred at all times, keeping it uniform. The proper temperature is maintained on the coating in the working pot by gas-fired horizontal-type burners situated beneath the pot and protected by an insulated firebox. Fresh coating material in a molten state is added continuously to the working pot from auxiliary melting pots. Asbestos felt and kraft paper reels are placed so that these wrapping materials are applied to the pipe while the coating is still molten, effecting a good bond and obtaining a homogeneous mass. Each of the five plants is equipped with a holiday detector to assure that the equipment is operating properly and that coating and wrapper are being applied according to specifications and the finished pipe does not contain any voids, or "holidays." The end of the pipe as it leaves the paper reel is placed on a "buggy" that runs on a track. The other end of the pipe joint is caught by a "breakout buggy" and the pipe is rolled onto the finish rack. Sometimes this pipe is used immediately, sometimes it is left in stock by the customer until needed, the yard containing ample room for such "stocking."

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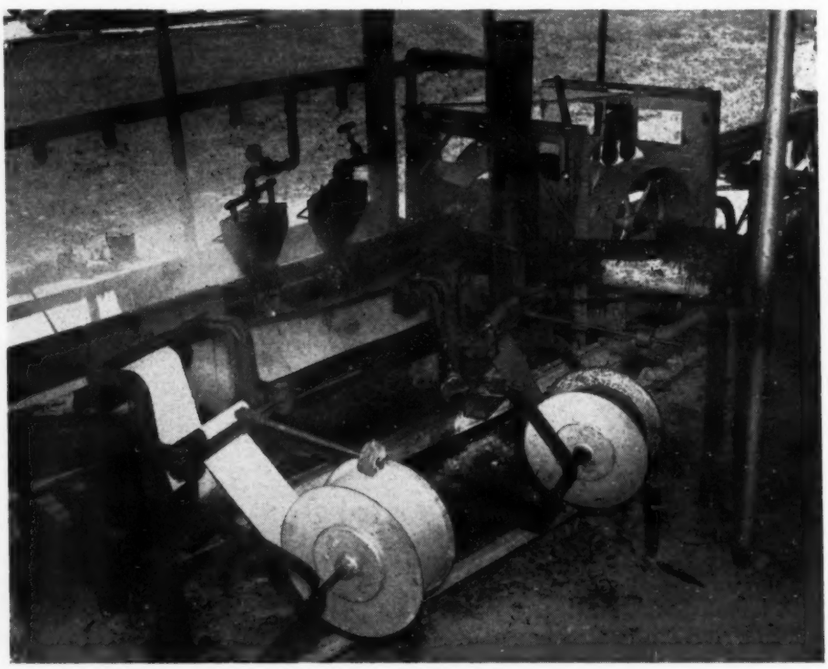

Coating is flooded over pipe from hoppers. Asbestos felt and kraft paper reels are shown in lower foreground

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Communication and Signaling Features On New Line

PETROLEUM ENGINEER EXCLUSIVE Feature

☆ **Installation that enables chief dispatcher to know at all times exact pressure at five points on the line aids in locating leaks**

by L. E. Adler

Communication Engineer, Magnolia Pipe Line Company

IN previous articles,[1] the writer placed particular stress upon the "poisonous" effect of laterals or side-lines upon main-line telephone transmission.

In the case of the Vanderbilt-Beaumont line, recently completed in Texas by the Magnolia Pipe Line Company, the line should and would have been engineered as a loaded underground cable job, buried with the pipe. Various and abnormal conditions militated against this procedure at the time, however, which resulted in the stringing of an open-wire line, chiefly on railroad routes.

By referring to Fig. 1, the reader can readily perceive from the great number of laterals what a transmission "headache" is involved. There is a total of 17 laterals, ranging from 1 mile to 11 miles in length; all necessary in order to reach the valve locations in the pipe line, as the railroad pole-lines do not closely parallel the pipe line itself at any point.

Let us now take a little "time out" and calculate the resultant transmission losses at 1000 cycles in terms of the "decibel" (unit of telephone transmission measurement) thus:

Vanderbilt to Houston (100 miles):

Loss over main line without laterals (miscellaneous cable and open-wire)	8.2 d.b.
Losses in equipment (simplex, coils, P.B.X. switchboards, carrier line filters, etc.)	3.5 d.b.
Cumulative bridging loss of 11 lateral lines	8.3 d.b.
*Total loss (Vanderbilt to Houston with no intermediate stations "listening-in")	20.0 d.b.

Houston to Beaumont:

Loss over main line without laterals (including cable and open wire)	7.6 d.b.
Loss in equipment (simplex coils, P.B.X. switchboards, carrier line filters, etc.)	3.0 d.b.
Cumulative bridging-loss of 6 assorted lateral lines	4.8 d.b.
Total loss (Houston to Beaumont with no intermediate station "listening-in")	15.4 d.b.

Vanderbilt to Beaumont:

From the foregoing summary, it is obvious that with an end-to-end call switched through at Houston, the total overall loss becomes 35.4, or 3.4 d.b. less than the so-called "commercial-limit" of 32 d.b.

Of course a great improvement in transmission as well as signalling could be effected by the use of an elaborate system of "triad-connected" repeaters placed at junction-poles and in fields. Such a procedure, under geographical, lightning, and maintenance conditions, however, not only would be very costly, but in many cases impracticable, especially when carrier-service is also involved.

In regard to this particular problem, full advantage was taken of certain conditions to permit a more economical and reliable answer in the following manner:

(a) As all laterals to the valves are terminated in small stations and used only by line-walkers in event of emergency, these lines may be normally disconnected from the main line at the junction-pole until actually needed. To

[1] "Pipe-Line Communication Practices," by L. E. Adler, March and October, 1941, The Petroleum Engineer.

L. E. ADLER

for 18 years was central office equipment engineer with Southwestern Bell Telephone Company—For 17 years he has been communication engineer for the Magnolia Pipe Line Company and during the last 16 years has also acted in the capacity of consulting communications engineer for pipe-line, railroad, and power companies relative to their private communication systems—Is a member of the American Institute of Electrical Engineers.

*When any intermediate station "listens-in" on a main-line conversation, the bridging loss for each such station increases from an average of 0.8 d.b. to approximately 2.8 d.b.

Fig. 1. Wire line diagram of Vanderbilt-Houston-Beaumont dispatching circuit

SYMBOLS

P = phone
L = #1-B lateral cut-off unit
M = metameter junction unit
MR = metameter recorder (pressure as indicated)
MT = metameter transmitter (pressure as indicated)
CT = telephone carrier terminal
PD = physical drop
CD = carrier drop

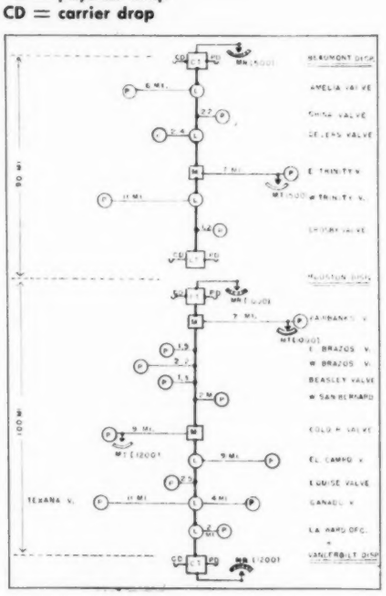

Fig. 2. Lateral cut-off unit (#1-B). Front view with cover removed

accomplish this automatically, the #1-B lateral cut-off unit was designed (see Fig. 2). This unit is equipped with a control-relay, a special insulating transformer, signal resistor, protectors, 6-volt lantern-type battery, and by-pass switch, all mounted in a weather-proof steel box. In connection with the #D-155 inductor at the small station end (see Fig. 3), the entire lateral is disconnected from the main line except when the valve-telephone is in actual use.

(b) The bridging-loss, even with the telephone in use, is only 1.6 d.b. instead of the usual 3 d.b., due to special design features in the #D-159 transformer to provide a smaller bridging-loss and a higher insertion-loss. The #D-159 transformers will also, in most cases, take the place of the usual side-line filter on carrier-operated lines.

(c) As the current required to operate the control relay is very small (4 to 8 ma.) the 6-volt lantern-type dry-battery will last almost as long as "on the shelf" or until it finally dries out or goes dead from its own internal leakage.

(d) Another advantage of the cut-off unit is that wire troubles on the lateral cannot affect the main line unless a sufficiently low-resistance ground operates the control relay. Even this possibility can be eliminated on single-station laterals by putting the 6-volt lantern battery at the small telephone station instead of in the #1-B cut-off unit. In this case, the battery connections must be bridged across in the cut-off unit box to provide straight ground on the relay winding instead of grounded battery.

(e) By referring to Fig. 1, it will be seen that six of the longer laterals are equipped with junction cut-off units, all of which reduces the total overall transmission loss between Vanderbilt and Beaumont from 35.4 d.b. to approximately 23.8 d.b., which provides a commercially good circuit between those points without the use of telephone repeaters.

(f) Unlike the ordinary simplex coil, the inductance of the #D-155 inductors and the D-159 transformers is

Fig. 3. Line circuit — lateral line equipped with No. 1-B lateral cut-off unit and associated apparatus

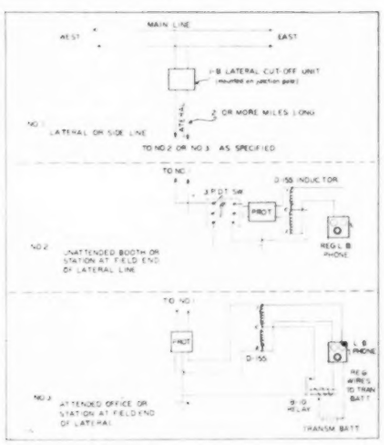

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Fig. 4. Typical metameter transmitter station and gas-valve installation. Building is ventilated, insulated, and insect-proof

so high that they have no appreciable effect on the 20-cycle ringing.

Carrier Transmission

Thus far we have dealt with the transmission features of the physical circuit only. Fortunately, the effect of the numerous laterals on the main-line carrier channel is almost negligible as either side-line filters or #D-159 transformers are provided at all lateral junctions. These devices will not pass any appreciable amount of high-frequency current, hence no carrier-current escapes into the lateral-lines.

The "Metametering" System

The metameter method of transmitting remote meter-indications consists of transmitting an impulse or signal current from the transmitter to the receiver or recorder, where it operates a relay controlling a mechanical linkage system having either a telechron or spring-driven unit. The value of the reading indicated on the scale is based entirely on the time-duration of the impulse received from the transmitter.

Although the particular meter function outlined herein is that of pressure, it is equally practicable to transmit on the same general principles many other types of measurement, including voltage, current, temperature, flow, etc.

Most of our readers are experienced engineers, operating men, or technicians, all of whom are already familiar with the purpose and need for this and similar long distance metering projects. However, it might be well to stress the major advantage involved, i.e., the net result of this particular installation is to enable the chief dispatcher to know at all times the exact pressure at five equally-spaced points over the entire line. Then in the event of a line leak or obstruction, a rapid fire calculation can be made and the approximate location of trouble quickly established. Otherwise, it would be necessary to locate the line walkers somewhere enroute and have them travel to the various valves to obtain spring-gauge readings. The delay involved might in some cases result in losses greatly exceeding the cost of the entire metameter system, to say nothing of the increased public hazard.

The same condition of numerous laterals that affected transmission and maintenance of the telephone channels on the Vanderbilt-Beaumont circuit also complicated the metameter prob-

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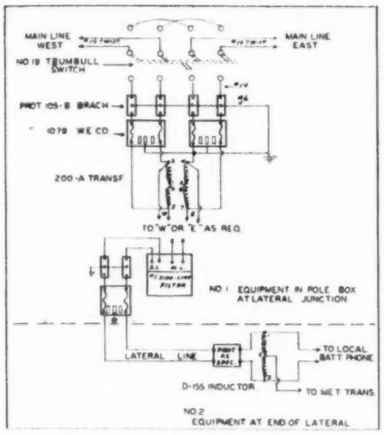
MAIN LINE WEST
MAIN LINE EAST
NO 19 TRUMBULL SWITCH
PROT 105-B BRACH
200-A TRANSF
TO "W" OR "E" AS REQ
NO 1 EQUIPMENT IN POLE BOX AT LATERAL JUNCTION
LATERAL LINE
TO LOCAL BATT PHONE
D-155 INDUCTOR
TO MET TRANS
NO 2 EQUIPMENT AT END OF LATERAL

Fig. 5. Metameter signal circuit arranged to operate over lateral using high-impedance inductor. Main line equipped with telephone carrier

lem. A partial summary of the various conditions to be overcome is as follows:

(a) All transmitters are situated at the end of laterals.

(b) A plurality of intermediate simplex coils introduced in the telephone line made it necessary to use repeating coils having a fairly flat response of 20,000 to 21,000 cycles, as these coils must also pass carrier-frequencies.

(c) The use of simplex coils also at the transmitter end would have seriously lowered the ringing-efficiency of the circuit. For this reason, the #D-155 inductor was developed. This has a very high bridged inductance (about 30 Henries), but a relatively low d-c. resistance when center-tapped for ground return.

(d) The necessity of placing sideline filters at the junction pole, as well as the simplex coils, protectors, bypass switches, etc., made it necessary to design a weatherproof steel box to house the equipment. The entire assembly is called a "metameter junction unit." Fig. 4 shows such a unit in service at Fairbanks valve. No. 1 in Fig. 5 shows the circuit diagram of the unit. No. 2 shows the wiring of #D-155 inductor in the transmitter booth at the end of the lateral.

(e) A complete schematic diagram of the entire metameter line "hook-up" is shown in Fig. 6. As will be noted, the entire method of operation is exactly analagous to a simplexed Morse circuit operated in sections. For those who may be faced with the need of transmitting two or more channels over the same paths, it is well to remember that carrier-telegraph of the multi-channel type is available for this purpose.

The #P-200 power unit is an a-c. operated, full-wave, thoroughly filtered rectifier unit employing the '83 type tube. It is adjustable from 90 volts d.c. to 175 volts d.c. without the use of series resistor. The voltage values are controlled entirely by a 6-point double dial switch that changes tapped connections on the plate winding of the power transformer.

The following protective features for the power-supply unit are almost imperative:

(a) Install #105-B (or equal) protectors on the a-c. secondary or 110-volt leads to the input side of #P-200 unit.

(b) Fuse the "hot" side of a-c. input with not more than a 3-amp. plug fuse.

(c) Insert a 100-watt or 75-watt, 110-volt lamp in the grounded side of a-c. input. This serves as a ballast lamp in case a "dead" ground occurs on the simplexed line and protects the rectifier tube from destruction by prolonged overload. Be careful that the lamp employed does not lower the normal a-c. voltage across transformer primary below 100 volts during the pulse-transmitting period.

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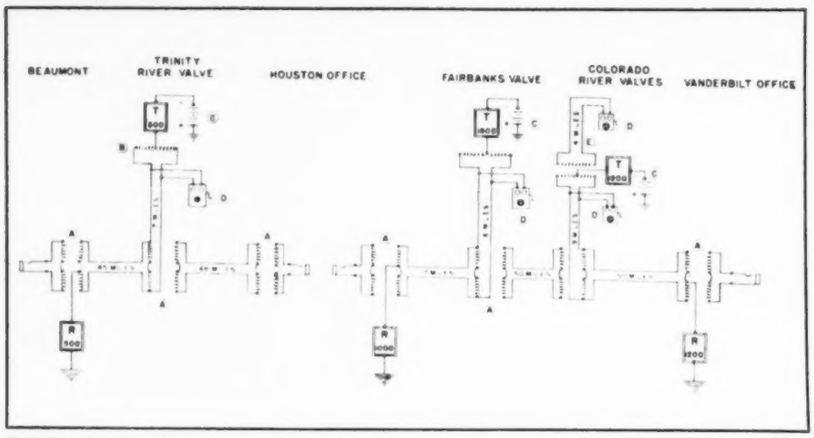

Fig. 6. Schematic diagram of metameter system on natural gas pipe line of Magnolia Pipe Line Company from Vanderbilt to Beaumont, Texas

APPARATUS CODE

A—No. 200A repeater coil
B—No. D155 inductor
C—No. P200 power unit
D—No. local battery telephone
E—No. D159 transformer
R—metameter recorder (pressure as indicated)
T—metameter transmitter (pressure as indicated)

What Not to Do

In conclusion, here are a few "don'ts" that apply to metameter installations in general, especially when operated over simplexed telephone circuits:

Don't install the d-c. power at the recorder end. Place it at the transmitter or as near thereto as possible; otherwise, the combined line leakage will cause "sticky" relay trouble.

Don't use an unfiltered rectifier unit for d-c. power unless you want to risk a high noise-level on your physical telephone circuit.

Don't use a d-c. power-unit having a high internal resistance. A better method of protecting the rectifier tube from "dead" ground on line is to use a properly designed ballast on a-c. input that will de-energize the filament or "heater" to minimize the false load.

Don't guess at the amount of operating current flowing through the receiver relay. Install an inexpensive 0-100 milli-ammeter and adjustable rheostat in series with the receiver circuit, situated so as to be in constant sight of the attendant.

Don't install delicate transmitter or receiver equipment in a "tin-can" type small station and expect it to be immune from trouble due to abnormal temperature extremes, condensation, rain, mud-daubers, etc. Build a substantial 4 ft. by 5 ft. (inside) wooden house with inner-walls and ceiling of celotex or sheetrock, equipped with screened roof, door and ceiling vents, and rainproof louvers (see Fig. 4).

——☆☆☆——

P 031.132

U. S. Bureau of Mines Reports on Study of Hydrates in Gas Lines

The formation of gas hydrates in natural-gas pipe lines depends on temperature and pressure conditions in the lines as well as on the presence of condensed water. The operating pressure in a pipe line may be determined easily and usually is available from the records of operation, but the temperature seldom is known. In coöperation

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with the American Gas Association, the U. S. Bureau of Mines, in its investigation of gas hydrates, conducted a pipe-line-temperature survey and studied underground temperatures at depths at which pipe lines ordinarily are buried and the relationship of these temperatures to prevailing atmospheric conditions. A similar but more limited study of this type was conducted by engineers of the Bureau of Mines a number of years ago. A summary of the earlier findings was included in a general report by the Bureau on the flow of natural gas through high-pressure transmission lines. In the present study, data on temperature variations were obtained at several places widely separated geographically. This information should assist pipe-line engineers in designing and operating natural-gas pipe lines.

In the pipe-line-temperature survey here reported (Report of Investigations 3590 by W. M. Deaton and E. M. Frost, Jr.) a study was made along a 22-in. natural-gas pipe line originating near Amarillo, Texas, and extending northwestward through New Mexico into Colorado. Some data also were collected along a 16-in. line extending southward from Amarillo. In the study of underground temperatures and their variation with atmospheric temperatures, recording equipment was installed at the Bureau of Mines stations at Amarillo, Texas, and Laramie, Wyoming. Underground-temperature observations were taken over a period of approximately four years, and the data obtained are included in this report.

The work was conducted under a coöperative agreement between the Bureau of Mines and the American Gas Association. The study was part of the work of the Amarillo, Texas, station of the Bureau of Mines and was conducted under the general supervision of R. A. Cattell, chief engineer, Petroleum and Natural-Gas Division, Bureau of Mines, Washington, D. C., and C. W. Seibel, supervising engineer, Amarillo Helium Plant, Amarillo, Texas. Acknowledgment of coöperation is accorded H. P. Rue, supervising engineer, and other members of the staff of the Bureau of Mines station at Laramie, Wyoming, particularly Walter Murphy, who gave considerable time and attention to the maintenance and operation of the temperature recorder installed at Laramie.

Acknowledgment also is made of assistance given by the management and engineers of the Canadian River Gas Company, the Colorado Interstate Gas Company, and the West Texas Gas Company, along whose pipe lines many of the data were collected.

——☆☆☆——

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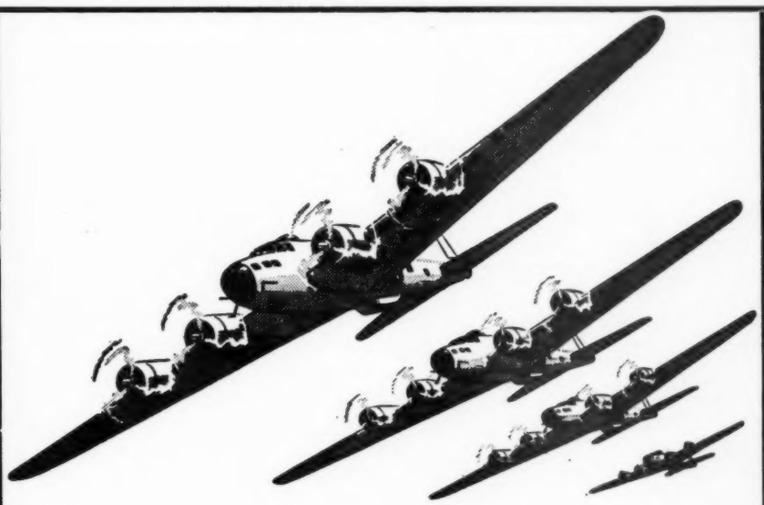

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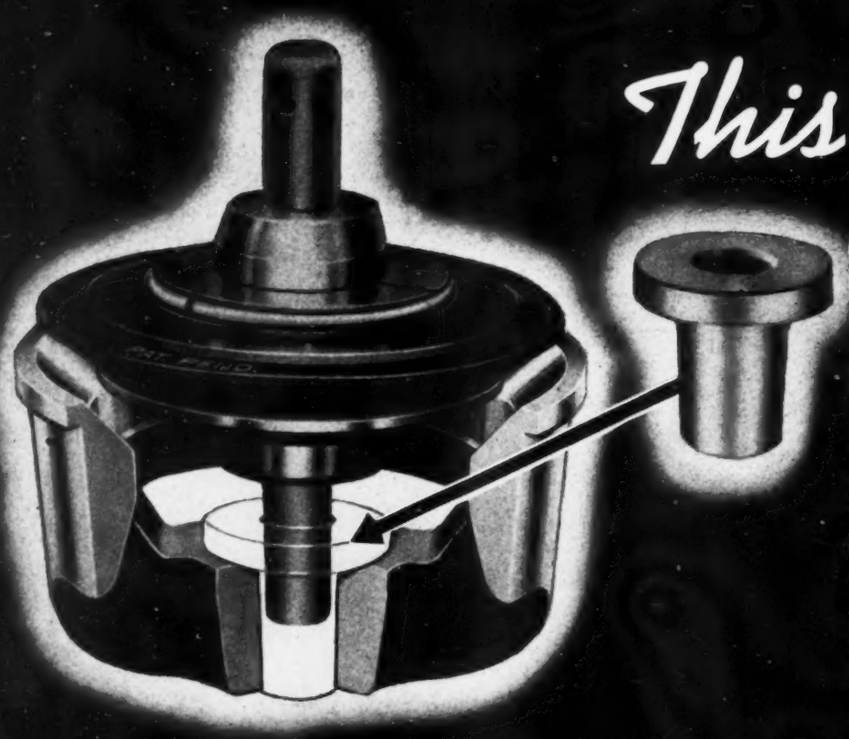

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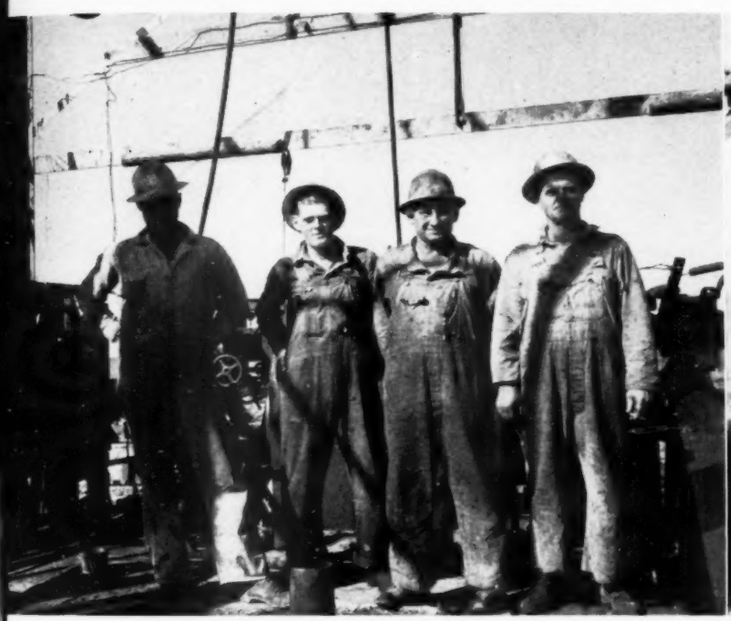
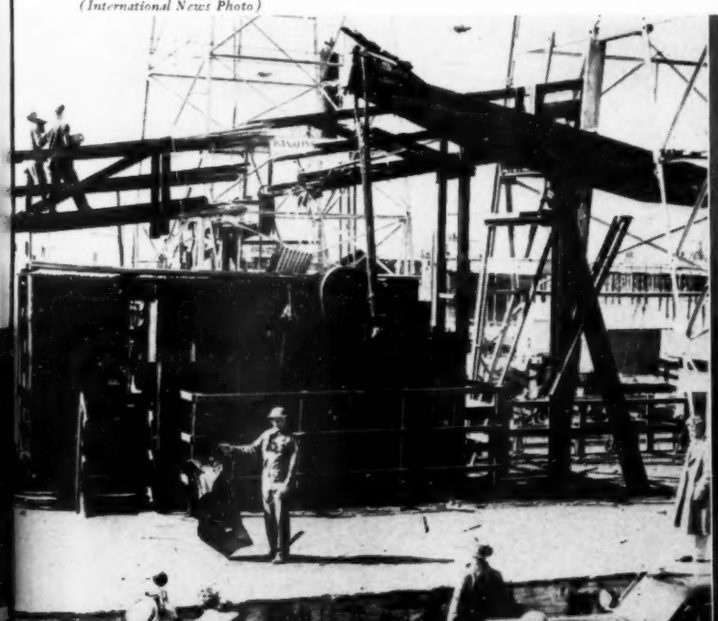


Stratton Drilling Company rig No. 2, Stratton field, Texas. Left to right: P. L. Wofford, derrick man; B. R. Brannon, floor man; G. B. Owen, driller, and W. I. Stephens, fireman.

On floor of Stratton Drilling Company rig No. 1 in Stratton field. Front row, left to right: Pete Bailey, driller's helper; Byron Beasley, derrick man, and E. C. Carter, pumper. Back row, left to right: Bill Collins, fireman; Roy Troutman, driller, and John Burge, driller's helper.

The only direct hit scored by the Japanese submarine that rose out of the sea a half mile off Ellwood, California, was to this pumping well in the Ellwood field.

(International News Photo)



New officers, Los Angeles Chapter of Nomads, taken at Third Annual Inaugural Ball. Left to right: (Seated) Roland E. Smith, sergeant-at-arms; W. F. Bettis, president; E. M. Rees, vice-president; Elmer L. Smith, treasurer; (standing) J. C. Ballagh, assistant secretary; E. B. Fowks, National Regent, and D. B. Waite, assistant treasurer.

A. P. I. Southwestern District Meeting

DALLAS, TEXAS

R. O. Garrett, Arkansas Fuel Oil Company, Shreveport, Louisiana, new chairman Southwestern District Division of Production.

J. Daviss Collett, Jr., Consulting Engineer, Houston, Texas, new vice-chairman for Texas Gulf Coast.

D. R. Knowlton, Director of Production, Office of Petroleum Coordinator (center) surrounded by oil men seeking information.

Snapped in the Adolphus Hotel lobby. Left to right: Stanley Morian, Dowell Incorporated, Houston, Texas; M. L. Stirling, Dowell Incorporated, Tulsa, Oklahoma; Tom Holcombe, Ark-La-Tex Gas Company, Shreveport, Louisiana; W. S. (Buck) Morris, East Texas Engineering Association, Kilgore; C. E. Mangold (back of Morris), Dowell Incorporated, Shreveport; D. A. Dechman, Cities Service Oil Company, Houston, Texas, and Fred Holland, Dowell Incorporated, Fort Worth, Texas.

A serious discussion between L. L. Rector (left) Rector Well Equipment Company, Fort Worth, Texas, and W. R. McLaughlin, Pittsburgh Equitable Meter Company, Dallas, Texas.

A. L. Vitter, Jr., Louisiana Department of Minerals, Oil and Gas Division, Baton Rouge, delivers paper.

Brad Mills (left) executive secretary, American Association of Oilwell Drilling Contractors, Dallas; Harvey Hardison, Standard Oil Company of Texas, Houston, and J. E. Warren, Carl B. King Drilling Company, Midland, Texas.

E. G. Dahlgren, technical secretary, Engineer's Committee, Interstate Oil Compact Committee, Oklahoma City, Oklahoma.

Johnny Best (left), Mission Manufacturing Company, Houston, Texas; J. U. Teague, Hogg Oil Company, Houston; F. A. Christanelli, Baroid Sales Company, Houston, and C. E. Bannister, independent operator, Tulsa, Oklahoma.

L. E. Tracy (left), Oil Well Supply Company, Dallas; Bryan Payne, Iowa-Payne Oil Company, Tyler, Texas, and John Bell, Humble Oil and Refining Company, Tyler.

Captain R. H. McLemore, U. S. Air Corps, formerly with Sun Oil Company, Dallas.

W. S. Crake, Shell Oil Company, Inc., Houston, Texas.

Glenn Staley (left) Proration Office, Hobbs, New Mexico; Joe Zaba, Rio Bravo Oil Company, Houston, and R. Guy Williams, Seaboard Oil Company of Texas, Dallas.

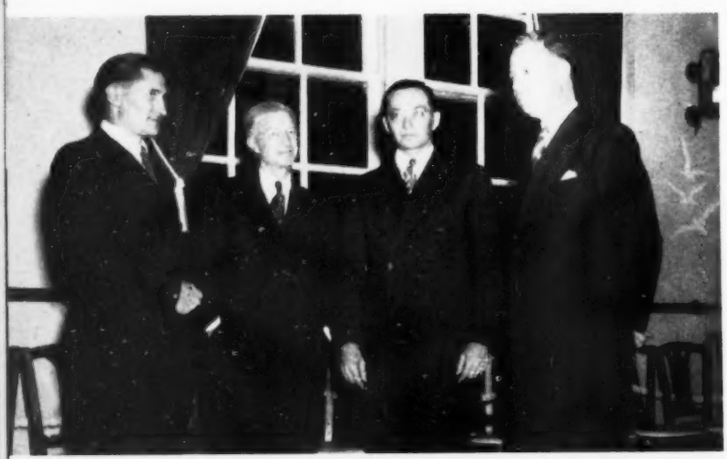
M. Schwarz, Seaboard Oil Company of Texas, Dallas, on duty as chairman of the Registration Committee.

Crowd around E. O. Buck (center) Assistant Director of Production, Office of Petroleum Coordinator, includes Bob Bowie, Cooper-Bessemer Corporation, Dallas; Thomas E. Brandon, Brandon Company, Odessa, Texas; A. E. Willig, The Texas Company, Fort Worth, and A. S. Donnelly, Honolulu Oil Company, Midland, Texas.

Petroleum Personalities

— South Texas

Elmer Ward (left), chief engineer, Chicago Corporation's Wardner Plant; J. A. Grimshaw, chemist, Wardner Plant; W. R. Brown, operating superintendent, The Chicago Corporation and Gulf Plains Corporation; E. B. Mack, engineer, Stearns-Roger Manufacturing Company; R. R. Branch, Texacone Packing Company. Photograph taken in Chicago Corporation's Wardner Plant office, Stratton field, Nueces County, Texas.

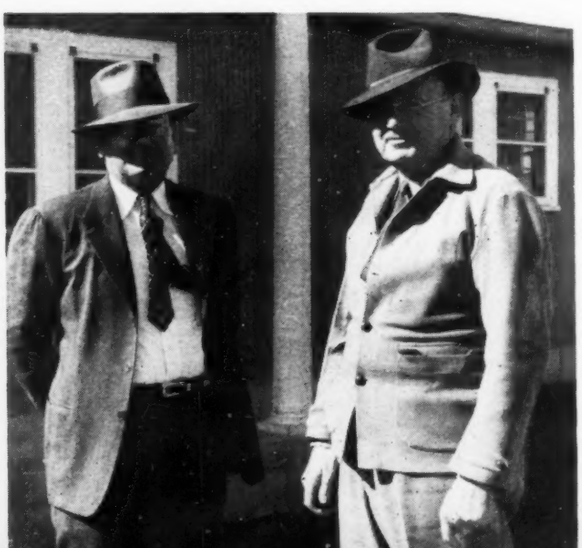


Left to right: Dr. George Fancher, professor of petroleum production, University of Texas; H. H. Power, professor of petroleum engineering, University of Texas; Don Harlan, petroleum engineer, The Texas Company; E. C. Sargent, Wellington Oil Company. Snapped at a meeting of Petroleum Industries Association.

R. L. Peurifoy, formerly of Texas A. and I., now in government defense service; C. C. Lee, The Chicago Corporation, and F. H. Dotterweich, professor of gas engineering, Texas College of Arts and Industries, Kingsville, Texas. (Picture taken at Petroleum Industries Association meeting.)

Upper: R. N. Corfield (left). J. S. Abercrombie Company; L. S. Wrightsman, Humble Oil and Refining Company; J. W. Northcutt, Pittsburgh Equitable Meter Company; H. Underwood, Jr., J. S. Abercrombie Company. Lower: Group picture of Petroleum Industries Association meeting.

W. R. Brown (left), operating superintendent of Wardner and Coastal cycling plants of the Chicago Corporation, Corpus Christi Division, and of Gulf Plains Corporation's cycling plant, and Clyde Alexander, who is an officer of the last-named and stockholder in the other two companies. Taken in front of Wardner plant office, Stratton field, Texas.



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By R. C. Johnston
R. C. Johnston
General Superintendent

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P 542.
P 615.4

Gathering System Designed for Gravity Flow in New Michigan Field

☆ **Eliminators that prevent air and free vapors from entering the system have been installed on flow tank batteries**

by J. C. Albright

TO prevent the unnecessary consumption of equipment that might be classified as National Defense materials, and at the same time to lower the cost of operation appreciably, the Pure Transportation Company recently constructed a gravity gathering system and an oil pipe line at Reed City, Michigan. The new field northwest of Reed City compares favorably with many of the larger pools of high flowing potential, the largest gauging approximately 12,000 bbl. daily. Instead of producing these wells to capacity, an allowable has been established that permits only 480 bbl. of production per day, and drilling is done on a 20-acre spacing, instead of 10 acres or smaller as in other areas.

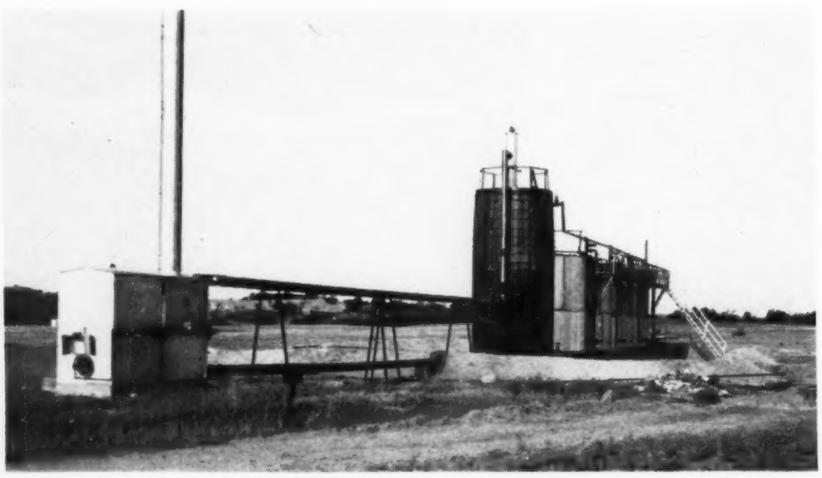
Plan of System

The major portion of the most productive area of this new field is in Osceola County, in a somewhat hilly country that provides a natural elevation, in some instances, of approximately 135 ft. higher than the loading rack at the railroad. After the discovery well was completed, which indicated a field of some prominence, Pure Transportation Company made an exhaustive survey of the topography, and decided from the results obtained that the oil could be moved from the tank batteries in the field to the loading rack with a minimum of pumping. The trunk and main gathering lines are 6-in. all-welded pipe, and the laterals from the flow tanks to the main lines range from 3 to 4 in. The operators in the field readily agreed to place their flow tanks on the highest part of the leases, thus providing as much head as possible for gravity flow in the gathering system so that use of pumping units could be avoided.

A 5000-bbl. steel storage tank was erected in the southeast portion of the field into which oil from the field batteries of lowest elevation can be run, and a second tank of like capacity was built at the loading rack in Reed City. A manifold system is connected to each tank so that the oil can be run directly into the tank, bypassed around it into the main trunk line, or bypassed around the tank into the pump station, if more oil is run from the field tank than can be put through the transportation system with gravity flow. The tank at the tank car loading rack has a similar manifold, but the pump at this location is used only to move oil

J. C. ALBRIGHT

for last 12 years has devoted virtually all his time to free-lance writing for trade journals—Began his career as drilling superintendent for H. J. von Hagen in North Texas area, 1919-1921—With the Noble Oil and Gas Company, Burkburnett, Texas, from 1921 to 1923—Joined staff of the Dixie Gasoline Company in 1923, and became Texas manager—Employed by Phillips Petroleum Company in 1925 and was sent to New Mexico, where the company constructed a natural gasoline plant—Left Phillips in 1929 and for a time operated as a consulting engineer before taking up writing.



Wooden gun barrel and steel flow tanks that form a part of Pure's gravity system in Reed City field, Michigan

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from the tank into the railroad tank cars.

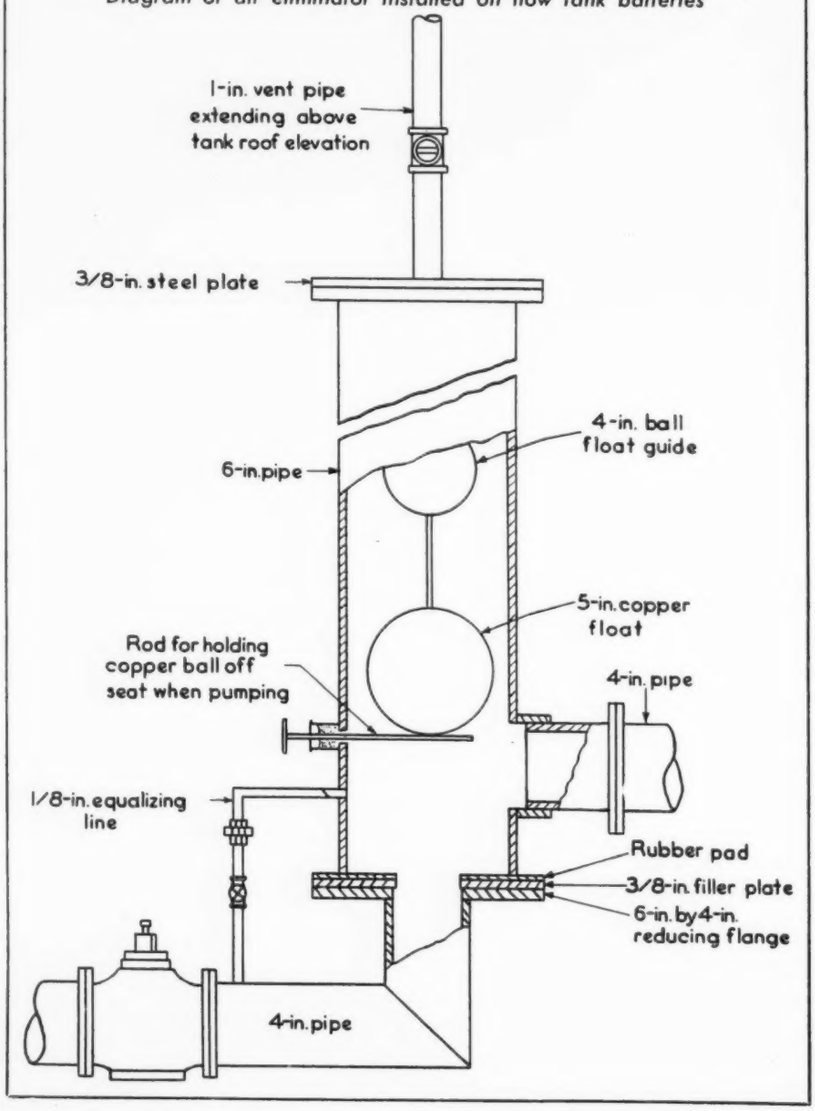
The operation of the pipe-line system has been simplified, but to make it as nearly foolproof as possible, careful planning was required before any of the pipe was strung or the ditches opened along the right-of-way. The laterals and main gathering lines were planned to follow natural surface drainage channels, which lead to the tributaries of the Muskegon River east of the field, and pass, where practicable, around the local elevations, instead of following a straight line from point to point.

Air Eliminators Installed

In any gravity system, air-lock in the lines prevents successful operation. In designing this system, a method was developed by engineers of Pure Transportation Company to prevent air from entering the lines with the oil. Air eliminators are installed at each group of field tanks and are fully automatic insofar as air elimination is concerned. These eliminators differ, however, from pipe-line vapor pocket venting apparatus. These units operate to *prevent* air and free vapor from entering the gathering system, rather than to *vent* such pockets once they have been formed.

The air eliminators are constructed of a 6-in. pipe 5 ft. in length and threaded on both ends. As they are designed to operate in a vertical position, the top end is equipped with a 6-in. flange to which a drilled ⅜-in. steel plate is bolted. In the center of this plate a 1-in. hole is drilled and tapped to receive a 1-in. pipe that is used to vent accumulations of air and/or gas. A 1-in. plug valve is connected in this line to open or close the vent as required. The base of the eliminator is equipped with a 6-in. to 4-in. reducing flange. A ⅜-in. spacer plate is set between these flanges and bored to a 4-in. opening. A gasket or pad of oil-proof rubber is attached to the filler plate, also finished with a full opening of 4 in. A 4-in. pipe collar welded on the eliminator case serves to connect the unit to the suction lines from the tank battery. This collar is approximately 4 in. above the top thread of the lower end.

Diagram of air eliminator installed on flow tank batteries



Inside the eliminator case is a 5-in. copper float ball to which a second ball is attached with a short separating stem. The latter ball is 4 in. in diameter, and assists in centering the larger ball on the opening of the oil-proof rubber pad, which forms the ball seat. In the side of the eliminator case is placed a stuffing box and packing gland through which a ½-in. rod is placed to lock the balls above the rubber seat, if and when it may become necessary to use pumps down-stream from the tank battery to move a greater volume of oil than will flow by gravity. It has been found that, if the velocity of the oil leaving the flow tank battery by pumping is sufficiently great, the float balls will have a tendency to follow downward through the case with the oil and consequently shut off the flow, if not held in suspension by means other than the natural buoyancy of the floats.

A 4-in. connection on the lower end of the eliminator case is equipped with a plug valve. The line is then reduced to 3 in. so that the velocity of the oil through the 4-in. valve seat is less than in the 3-in. line. Thus, less turbulence is created in the eliminator case than if the entire system was of the same pipe size.

Around the base of the eliminator and connected to the 4-in. line upstream from the plug valve at one point and the case at the other, is a ⅛-in. equalizing line. This line is used to return any air that may have passed the float seat to the eliminator case.

At the loading rack end, oil is either flowed directly into the tank cars or to the 5000-bbl. steel tank. The normal head of the oil in the 6-in. line is sufficient to load cars without pumping, but if oil has been stored in the 5000-bbl. tank, a motor-driven centrifugal pump, controlled from the loading rack doghouse, is used to transfer oil from the tank to the tank cars.

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So You Want to be a Petroleum Engineer?

PART 3—*Getting the Most Out of Your College Course*

by Lester C. Uren

Professor of Petroleum Engineering, University of California

"WELL, here again? Like to talk some more about that petroleum engineering course? It is well to get the full perspective of your college course before you get too far into it, so that you'll understand where it is leading you and so that you can appreciate fully its relationship to your subsequent professional career. You're going to work hard during these years in college and it's going to cost a lot of money that may not have been easy for someone to earn and save. So, let's plan to get the most out of it; let's not have any regrets later on for things we failed to do during these years of opportunity. And by the way, I hope that you do fully appreciate that this chance you have to get a college education is a real opportunity, probably one of the greatest opportunities that you will have during your entire life.

"A college education is not uncommon, but did you know that even in these days, only 13 percent of the young men of this country are able to attend an institution of higher learning, and only about two-thirds of these stay long enough to earn degrees? And do you realize what it is going to be worth to you, not alone in increasing your social opportunities and in equipping you for a professional career, but also in increasing your earning capacity? Some years ago, a large eastern university assembled data on the life-time earnings of two large groups of men. One group included some thousands of men who had received degrees from institutions of university or college grade. The other group comprised a large number of men who had graduated from high school but had not attended an institution of higher learning. Their average life-time earnings were estimated to be $72,000 less than the college-trained group. Most of the latter group had remained only four years in college. They had increased their life-time earnings at the rate of $18,000 per year! There are few years in a normal life when you can hope to earn so much. It may cost you as much as a thousand dollars per year to go to college, but society is still paying you $17,000 more per year for the time you spend there. Of course, we must recognize that the man who goes through college is generally a more ambitious, abler man than the one who does not, and he probably would have been more successful in any case, but a college degree pays big dividends any way you look at it. In most schools and colleges, the institution pays a considerable part of the cost. Some institutions provide as much as $500 per student per year toward the cost of maintenance and instruction. The average student may thus receive a free gift of $2,000 or more during his four undergraduate years, as a contribution toward his education.

Addressed particularly to the prospective petroleum engineering student, the current series of articles by Professor Uren will also be of interest to educators and employers of petroleum engineering graduates. The first installment of this series appeared in the January, 1942, issue of *The Petroleum Engineer*.

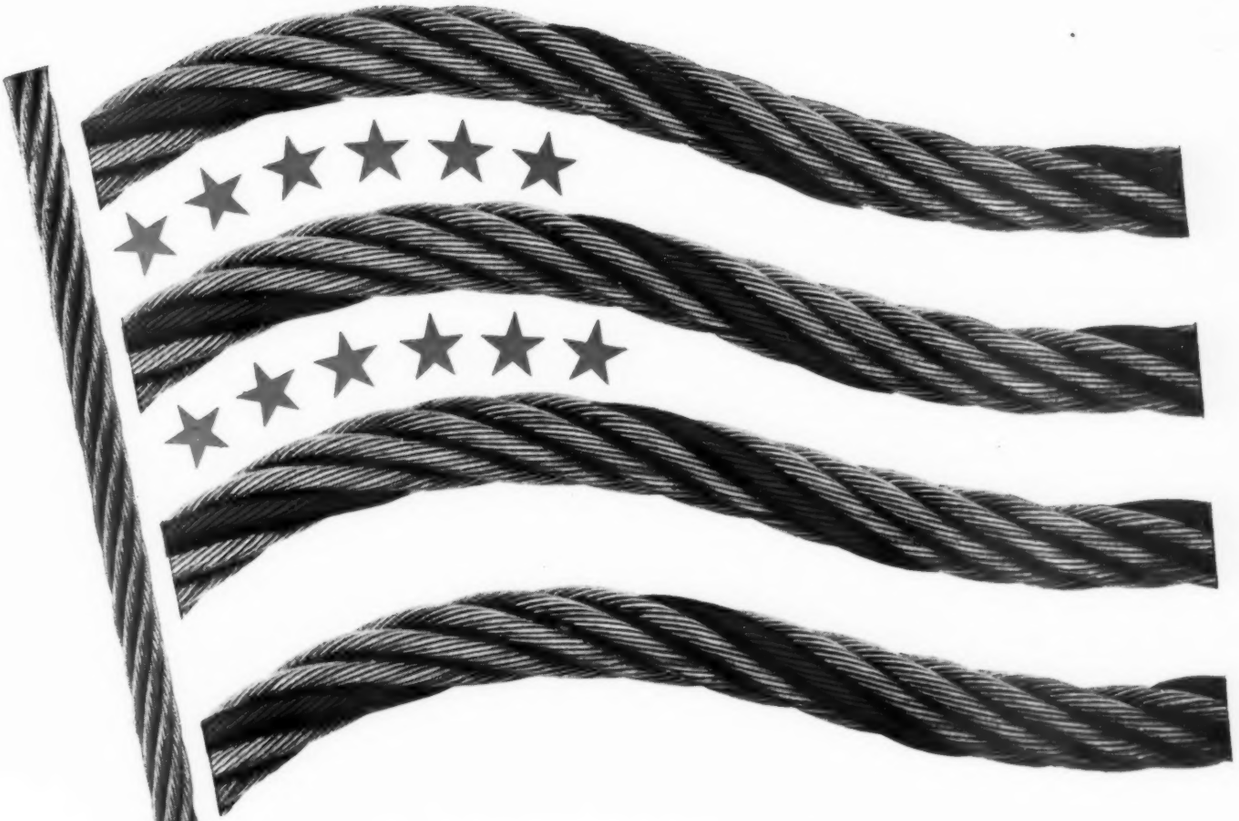
A photograph and biographical sketch of the writer can be found on Page 27 of the January issue of *The Petroleum Engineer*, in connection with Part 1 of this series.

How Many Years in College?

"If four years in college pays so well, perhaps more time would pay even better; and this leads us to a very important question that every young man entering upon a college course should ask himself: 'How long should I remain in college?' Most students are eager to become self-supporting: to complete their education and get started on their professional careers. Often, financing the college course has been a real hardship, not only on the student himself but to his parents, and each additional year adds to the burden. Perhaps money has been borrowed and the student is anxious to repay those who have assisted him in maintaining himself in college. However pressing these considerations may appear, one should try to gain a long-range view of the problem and if a year or two of additional time is advisable in 'rounding out' the educational process, the student should consider whether it may not be possible to spare this extra time and in some way find the additional funds that would be necessary. Perhaps a few years in industry after completion of the usual four-year program will permit the student anxious to extend his college course, to save enough for his support during a graduate year or two.

"Although most engineering curricula now offered by the universities and colleges of the United States provide a four-year terminal program, many educators have come to believe that additional time is necessary to equip the engineer fully for the more advanced phases of his profession. Particularly is this true in the field of petroleum engineering, and many employers of petroleum engineers are now suggesting to their prospective engineering employees that they spend a graduate year or two in college before assuming a permanent position. The usual four undergraduate years may be adequate in preparation for many oil company positions. For example, if the student plans to get a routine technical job in field operations with the hope of eventually achieving an administrative position in the field organization of his company, he may decide that the usual four-year undergraduate course is sufficient. For such an objective, it may well be that the additional time that might be spent in college could more profitably be spent in making progress in the 'practical' phases of oil-field work. But if the student wishes to perfect himself in some advanced technologic specialization within his chosen field, additional time in college will be advisable. The traditional four years are sufficient only to develop a foundation upon which the petroleum engineer may build. Real proficiency in some phase or phases of the work, or development of a broader foundation can only be attained by extending the period of training over a greater number of years.

"In most institutions offering petroleum engineering curricula, it is possible to plan an additional year or two beyond the usual four, including a program of advanced petroleum engineering courses and work in other closely related departments for which there has been insufficient time in the four-year program. Perhaps also, there will be time for a thesis affording opportunity for training in research methods. Often such a program will lead to an



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advanced degree. If extra time is to be available, it is well to plan for it in advance, concentrating the elective units allowed in most undergraduate curricula on courses that will provide a suitable foundation for the advanced specialization contemplated. For example, a student may wish to develop a specialization in the field of mechanical engineering to 'round out' the usual petroleum engineering course. Concentrating the undergraduate electives in this field and using a fifth year to 'mop up' additional desirable mechanical engineering courses, the student may usually complete the full equivalent of both the petroleum and mechanical engineering undergraduate curricula in a five-year program. Similarly, if the secondary interest is in the field of chemical engineering or geology and geophysics, a substantial program in either of these fields is possible in a fifth year. A fifth year with concentration on courses in economics and business administration will be of advantage to any engineer. Many students, however, will wish to spend any additional time that they may be able to afford in college, on their own particular field of interest; that is, on advanced courses bearing particularly on petroleum technology, affording opportunity for intensive study of the more technical aspects of petroleum engineering.

"Some institutions have definitely formulated five-year petroleum engineering curricula with secondary specializations in different directions, and at least one institution (Stanford University) has pioneered in offering six-year engineering curricula. Table 2 suggests several types of five-year programs and one six-year course that are possible at almost any of the institutions that offer instruction in the field of petroleum engineering. The broader basis afforded by these more extended programs will be apparent on comparison with a liberal four-year curriculum in petroleum engineering also included in Table 2.

"Some oil company executives apparently believe that the usual mechanical engineering undergraduate four-year curriculum is better preparation for a technical position in the oil-producing industry than the usual four-year petroleum engineering curriculum planned particularly for this purpose.

The excuse offered for this rather illogical assumption, is the belief that specialization should be avoided in the undergraduate course and that there is less of this in the usual mechanical engineering program than in other engineering curricula: that there is more emphasis on 'fundamentals' in the mechanical engineering course. That this is untrue will be apparent on comparison of any of the curricula displayed in Table 2 with almost any four-year mechanical engineering curriculum. The well-planned four-year petroleum engineering course may have just as much physics, chemistry, mathematics, and general fundamental engineering courses included in it as does the usual course in mechanical engineering. Indeed, it may be said that the petroleum engineering course includes more of the necessary fundamental subjects for it usually includes more chemistry and a substantial program in geology that the mechanical engineering program does not ordinarily touch. Surely no one may reasonably contend that a profession having as much to do with subsurface conditions as petroleum engineering does not need any academic training in geology.

The Value of Higher Degrees

"Increasing emphasis on the value of higher degrees as evidence of advanced academic preparation, has recently been noted in the attitude of many oil company personnel officers in dealing with prospective employees. Generally speaking, if the student is planning to spend five years or more in college, he may as well plan to meet the requirements of one or another of the higher degrees. The Master of Science Degree may usually be obtained at the end of the fifth year. The Engineer's Degree or the Doctor of Philosophy Degree usually require six years or more. Candidates for higher degrees are generally expected to maintain a higher standard of scholarship than is normally expected of undergraduate students, and must usually demonstrate more than ordinary ingenuity and originality by completion of a thesis or dissertation.

"Aside from personal satisfaction in superior attainment, greater bargaining capacity in obtaining employment and in commanding somewhat higher early earnings, the possessor of a higher degree will ordinarily find it advantageous in many professional relationships. For example, it confers a certain distinction if the engineer is qualifying as an expert in court litigation or in actions before government commissions and public agencies. In the consulting field, it gives added confidence

Table 2

Proposed Petroleum Engineering Curricula.

Subjects / "Semester Units"	Four-Year Petroleum Engineering	5-Year Petroleum Eng. Curriculum—Advanced Engineering Specialization	5-Year Petroleum Eng. Curriculum—Exploration Specialization	5-Year Petroleum Eng. Curriculum—Production Specialization	5-Year Petroleum Eng. Curriculum—Chemical Engineering Specialization	5-Year Petroleum Eng. Curriculum—Mechanical Engineering Specialization	6-Year Petroleum Eng. Curriculum—Advanced Engineering Specialization
Mathematics:							
Analytic Geometry	6	6	6	6	6	6	6
Differential Calculus	5	5	5	5	5	5	5
Integral Calculus	5	5	5	5	5	5	5
Differential Equations	4	4	4	4	4	4	4
Total Mathematics	16	16	16	16	16	16	16
Physics							
General Physics	12	12	12	12	12	12	12
Vector Analysis							3
Advanced Heat							3
Advanced Electricity & Magnetism							4
Advanced Dynamics		6				3	3
Total Physics	12	18	12	12	12	15	25
Chemistry & Chemical Technology							
General Chemistry & Qualitative Analysis	10	10	10	10	10	10	10
Quantitative Inorganic Analysis	3	3	3	3	3	3	3
Organic Chemistry	3	3	3	3	3	3	3
Physical Chemistry	3	6	3	3	7	3	6
Advanced Organic Chemistry; Hydrocarbons		3	3		3		3
Chemical Thermodynamics					3		
Colloid Chemistry					2		
Chemical Technology: Unit Processes					6		
Total Chemistry	19	25	22	19	37	19	25
Drawing							
Engineering Drawing	2	2	2	2	2	2	2
Descriptive Geometry	1	1	1	1	1	1	1
Machine Drawing & Design						3	3
Graphical Solution of Eng. Problems	1	1	1	1	1	1	1
Total Drawing	4	4	4	4	4	7	7
Geological Sciences							
General Geology: Dynamical & Structural	3	3	3	3	3	3	3
Historical Geology	3	3	3	3	3	3	3
Determinative Mineralogy	2	2	2	2	2	2	2
Crystallography	1	1	1	1	1	1	1
Petrology	3	3	3	3	3	3	3
Petrography			6				3
Field Geology: Mapping, Surveying	4	4	4	4	4	4	4
Tectonic Geology			2				
Economic Geology of Oil & Gas	3	3	3	3	3	3	3
General Paleontology			3				
Invertebrate Paleontology			3				
Micropaleontology			4				
Advanced Petrography: Mineral Grains			3				
Stratology			2				
Applied Geophysics			3				
Advanced Structural Geology			2				
Advanced Paleontology			2				
Total Geology	19	19	37	19	19	19	19
General Engineering Subjects							
Engineering Mechanics	6	6	6	6	6	6	6
Strength of Materials; Materials Testing	3	3	3	3	3	4	4
Fluid Mechanics; Hydraulics	3	6	3	3	3	3	6
Engineering Thermodynamics	6	6	6	6	6	6	6
Total General Engineering	18	21	18	18	18	19	22
Mechanical Engineering							
Power Development and Transmission	3	3		3	3	5	5
Internal Combustion Engines		3				3	3
Principles of Machine Design						3	3
Pumping Machinery; Fluid Transfer		3			3	3	3
Dynamics of Machinery						3	
Industrial Heat Transfer					3	3	
Total Mechanical Engineering	3	9	0	3	9	18	9
Electrical Engineering							
Electrical Circuits & Machinery	3	6	6	3	6	10	10

Subjects / "Semester Units"	Four-Year Petroleum Engineering	5-Year Petroleum Eng. Curriculum—Advanced Engineering Specialization	5-Year Petroleum Eng. Curriculum—Exploration Specialization	5-Year Petroleum Eng. Curriculum—Production Specialization	5-Year Petroleum Eng. Curriculum—Chemical Engineering Specialization	5-Year Petroleum and Mechanical Engineering	6-Year Petroleum Eng. Curriculum—Advanced Engineering Specialization
Civil Engineering:							
Surveying & Topographic Mapping	6	6	6	6	6	6	6
Graphostatics; Framed Structures							2
Materials of Engineering Construction							2
Applied Strength of Materials						2	2
Total Civil Engineering	6	6	6	6	8	8	12
Metallurgy:							
Metallurgy of Iron & Steel			2		2	2	2
Physical Metallurgy; Metallography			3			3	3
Industrial Utilization of Metals & Alloys					2		
Total Metallurgy	0	0	5	0	4	5	5
Petroleum Technology:							
The Petroleum Industry: Introductory	2	2	2	2	2	2	2
Oil-Field Development; Drilling Methods	3	3	3	3	3	3	3
Petroleum Production Methods	3	3	3	3	3	3	3
Petroleum Engineering Laboratory	4	4	4	4	4	4	4
Oil & Gas Testing & Gauging	2	2	2	2	2	2	2
Petroleum Transport & Storage			1			1	1
Natural Gas Production & Transmission			2			2	2
Oil-Field Mapping & Drafting Practice	2	2	2	2	2	2	2
The Natural Gasoline Industry						2	
Petroleum Refining; Unit Processes						3	
Fuels Technology; Combustion, etc.						2	2
Economics of the Petroleum Industry		3	3	3		3	3
Appraisal of Oil-Producing Properties			2	2			2
Reservoir Mechanics		2	2		2		2
Advanced Field Development Seminar		2	2			2	2
Advanced Petroleum Production Seminar		2		2			2
Advanced Petroleum Economics Seminar						2	2
Oil-Field Equipment Selection & Design		2				2	2
Petroleum Technology Thesis & Research							6
Petroleum Eng. Field Studies & Excursions							2
Oil and Gas Law						2	
Oil-Field Safety Practice; First Aid		1				1	1
Total Petroleum Technology	16	31	25	28	26	24	43
Economics:							
General Economics	6	6	6	6	6	6	6
Accounting & Cost-Keeping	2	2	2	6	2	2	2
Statistics				2			
Engineering Economics				3			
Industrial Organization & Administration				3			
Corporation Finance				3			
Labor Economics				3			
Industrial Relations				3			
Analysis of Financial Statements				2			
Total Economics	8	8	8	31	8	8	8
English:							
Composition & Rhetoric	2	2	2	2	2	2	2
Technical Writing; Report Writing	1	1	1	1	1	1	1
Speech Principles; Public Speaking	1	1	1	1	1	1	1
Total English	4	4	4	4	4	4	4
Jurisprudence:							
Commercial Law				3			
Engineering Contracts & Specifications				2			
Total Jurisprudence	0	0	0	5	0	0	0
Miscellaneous:							
American Government							
Military & Naval Science							
Physical Education & Hygiene							
Orientation Courses							
Restricted Electives							
Free Electives	8						
Grand Totals	136	172	172	172	172	172	208

Bottom Hole Information COMING UP!

Sectional view showing Core Barrel in Place for Coring.

The Easy, Modern Way

Yes, when operators drop the Hunt Retractable Wire Line Core Barrel they know that they are **coming up** soon with their "quota" of core — maximum recovery of footage cut.

Hunt Core Barrels have "come up" with dependable cores — positive sub-surface data — in fields throughout the world. More than 20 major companies and many well known drilling contractors have standardized on Hunt for better results. Put Hunt Core Barrels on your coring schedule for '42.

HUNT TOOL COMPANY

HOUSTON, TEXAS, U. S. A.

Field Shops: Bay City, Corpus Christi, Jennings, Shreveport, Harvey.
Export: W-K-M Company, Inc., 74 Trinity Place, New York City.

Equipment for A.P.I. well-pumping research project, University of Oklahoma

to prospective clients. The Doctor of Philosophy degree is helpful in obtaining a research or teaching position. Abroad, more importance apparently attaches to higher degrees than in this country.

Cultural and Inspirational Values

"Attending a college or university should mean something more than mere training for a profession. It is a place where one should acquire a philosophy of life, an outlook toward society, and a knowledge and understanding of cultural values that will enrich all future years. It is well deliberately to set aside some part of each day for things that do not relate directly to professional preparation: things that will assist in developing a more fertile soil upon which a truly educated mind may thrive.

"Consider the opportunities afforded by the environment in which the college student is placed. He becomes one of a large company of ambitious individuals, of higher-than-average intelligence, comprising a cross-section of the best elements of American life. The college youth of today are very largely the professional, political, and social leaders of tomorrow. The man who sits next to you in this class or that, and whom you may come to know intimately by close association, may some day be the directing head of a great industrial organization, a man of importance in the field of government, or in any one of many different posts. The friends one makes in college will often be those whom we value most highly in future years, not so much for the influence they may have in assisting our future careers, but more than this, because of the experience gained by association with young men of unusual brilliance and exceptional personality and its influence in developing like characteristics in others about them. Cultivate the acquaintance of those about you: seek their companionship; discuss with them the problems of the day. Nothing serves better to crystallize ideas and objectives than the give-and-take of student jam sessions.

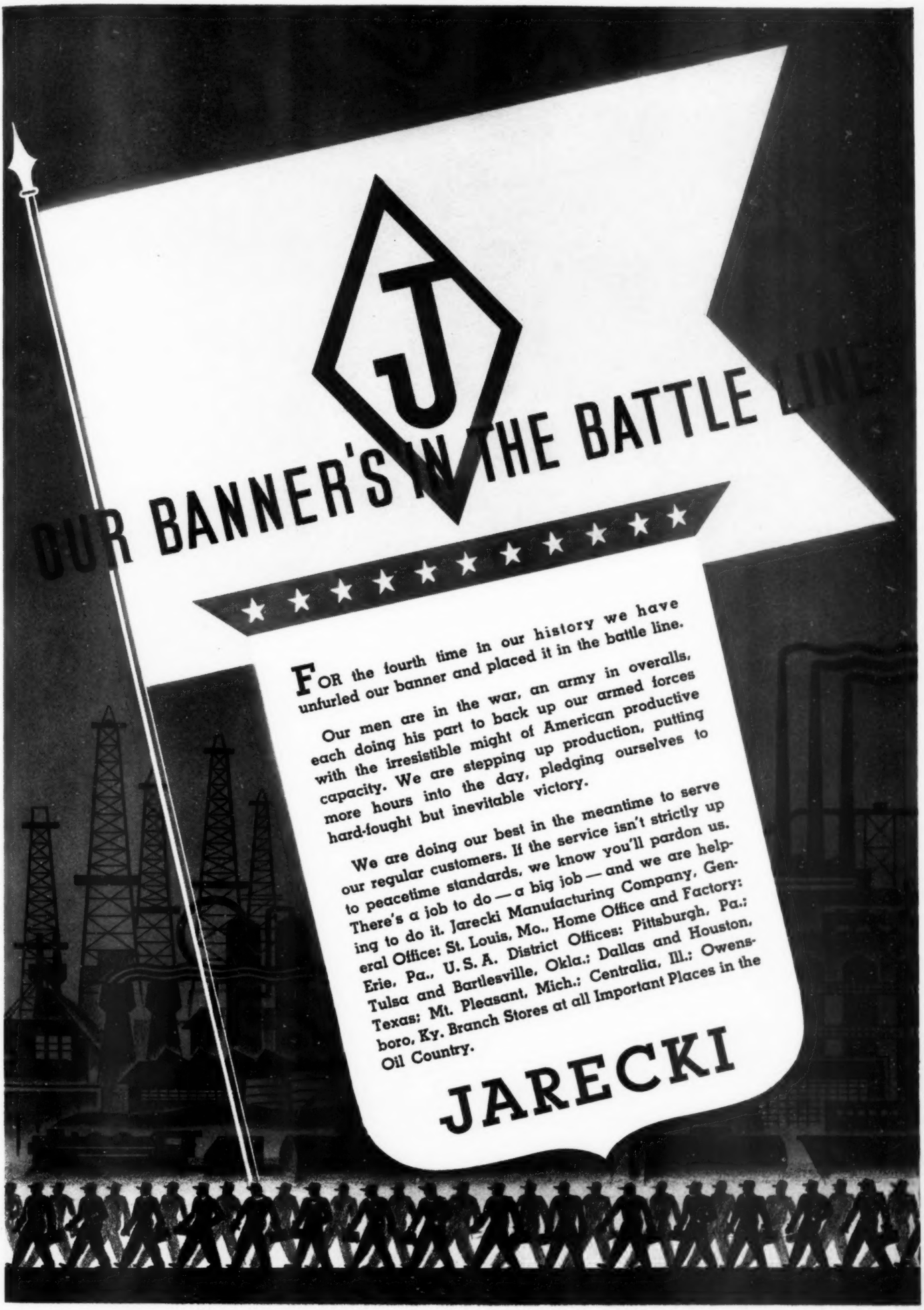
"And the college faculty, though they may appear a 'stuffy' lot to their more youthful and 'worldly' students, nevertheless individually offer a rare opportunity for inspirational experience. Each one is an authority in his particular field, perhaps an internationally known authority. Consider the concentrated wealth of knowledge that can be brought to bear in a great university on almost any subject in which the student may be interested: advice and knowledge that cost years of patient study and research, available at almost no cost to the student.

"Among the faculty of every college or university are at least a few men who by their enthusiasm and devotion to their teaching become an inspiration to all about them. In the course of time such men have hundreds, perhaps thousands, of student disciples who carry into their professional careers something of inestimable value that they acquired through the casual relationships in college courses. The ambitious student will do well to seek personal contacts with such men: to 'shop around' for elective courses of inspirational value, even though they may seem quite unrelated with the student's immediate professional objective. A professor of English literature or political science or astronomy may contribute more to the ultimate stature of a petroleum engineer than the professor of petroleum engineering. The greatest teacher is not the man who conveys information or explains how to do things, but the one who inspires in his students a desire and a will to do things.

"The college or university as an educational center affords many opportunities to the student community for cultural experience. Special lectures on a wide variety of topics by visiting celebrities, music, drama, motion pictures of educational value, technical and professional society meetings, are the almost daily fare of those who make most of their educational opportunities. Libraries, museums, and art collections present opportunities for cultural development seldom available to the petroleum engineer in his later professional environment.

Extra-Curricular Activities

"Most colleges and universities support a complete program of student 'activities' and every student should look for one among them in which he will find enjoyment and healthful recreation. Sports attract the greater number of male students, but the more cultural activities, including debating, journalism, music, dramatics, photography, etc., appeal to many. A balanced program including a selection of one among the many sports for exercise, and one or another of the cultural group of activities for recreation and social contacts, is a happy solution. Comparatively few can hope to qualify


OUR BANNER'S IN THE BATTLE LINE
FOR the fourth time in our history we have unfurled our banner and placed it in the battle line.
Our men are in the war, an army in overalls, each doing his part to back up our armed forces with the irresistible might of American productive capacity. We are stepping up production, putting more hours into the day, pledging ourselves to hard-fought but inevitable victory.
We are doing our best in the meantime to serve our regular customers. If the service isn't strictly up to peacetime standards, we know you'll pardon us. There's a job to do — a big job — and we are helping to do it. Jarecki Manufacturing Company, General Office: St. Louis, Mo., Home Office and Factory: Erie, Pa., U. S. A. District Offices: Pittsburgh, Pa.; Tulsa and Bartlesville, Okla.; Dallas and Houston, Texas; Mt. Pleasant, Mich.; Centralia, Ill.; Owensboro, Ky. Branch Stores at all Important Places in the Oil Country.
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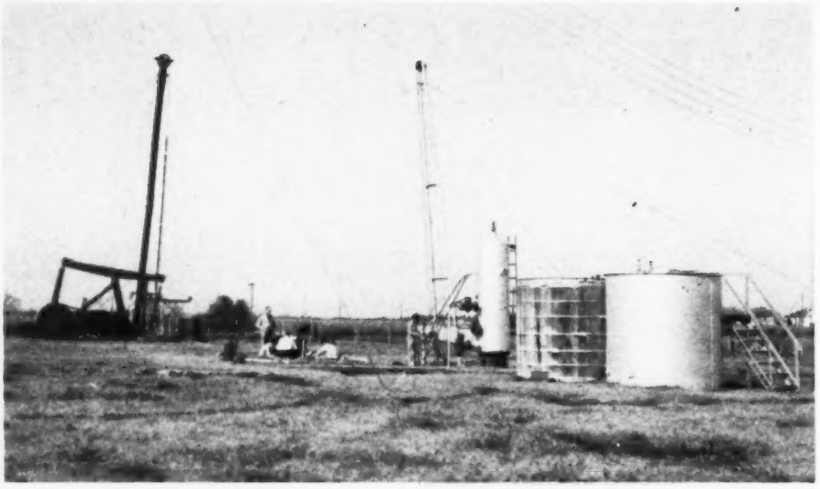


Experimental "oil field," Texas A. and M. College

for competitive teams but intramural sports activities provide healthful, recreational opportunities for all.

"Although extra-curricular activities are to be encouraged, the student must be careful that he does not allow them to occupy a disproportionate part of his time. Academic scholarship records too frequently show the scars of over-indulgence in football, baseball, track, or other sports that may lead the student in his enthusiasm momentarily to lose sight of the ultimate values in a college education. Yet, who can say that the rugged constitution, popularity among his fellows, and training in the principles of good sportsmanship, that are the usual products of a successful athletic career in college, do not contribute much to later professional success?

Organization and Non-organization?

"To most students the opportunity is presented to become a member of a student fraternity or house club, and the decision regarding whether or not one should assume the obligations that such membership involves should receive careful consideration. The urge 'to join' is deep-rooted in most of us; we want to be one of the group, especially if membership in the group seems to confer on its members added prestige or social position. There is no doubt that most students profit greatly by the close friendships formed in clubs and fraternities and by the 'give-and-take' way of living among one's fellows, that rubs off rough corners and leaves a better rounded, more social individual, better able to deal with men in the world of affairs. Shy, self-conscious, and unsociable students particularly need this training. Fraternity life is a good antidote for an 'inferiority complex.' The 'lone wolf' type of student who shuns social contacts with his fellows definitely needs the kind of life that the club or fraternity group affords. On the other hand, the 'good mixer' type is apt to be led by the fraternity atmosphere into an over-indulgence in social activity to the disadvantage of his scholarship record. It cannot be denied that the environment of many house clubs and fraternities is not conducive to studious habits; however, the well managed 'houses' have ways of correcting this tendency. Yet, it is generally true that non-organization students as a group have a higher average scholarship than that of the fraternity and club group, notwithstanding the fact that the processes of selection by which the latter recruit their membership might be expected to result in a group capable of superior attainments.

"The question of whether fraternities violate the fundamental principles of democracy and lead to social and political cliques destructive to the best traditions of American college life, is one that is often raised, but an impartial study of the influence of the organized groups will show that on many college campuses they have been a powerful force for better student government and often provide needed organized leadership in campus affairs. Unfortunately, many worthy students are unable to afford membership in a fraternity and the resulting economic cleavage tends to build an artificial and undesirable barrier between the organized and unorganized groups. Every student must decide for himself whether or not he would profit by membership in a club or fraternity, and he must not be hasty in accepting the first offer of membership extended. Before doing so, it is well to inquire carefully into the character of the membership, their scholarship status, and the social position and business reputation of the group in the community. The Dean of Men or some other equivalent officer can usually supply information of this kind to the prospective initiate.

"The above discussion of fraternities and clubs obviously does not apply in its entirety to 'honor' fraternities and societies. Few of the disadvantages that have been suggested and all the advantages apply to these organizations. Generally membership in these groups may be regarded as a reward for superior scholarship or leadership in some phase of student activities. Their tendency is to bring together superior students having common interests and objectives, and membership in them should be welcomed by the student whenever offered. Indeed, membership in some of the better known honor societies, such as Phi Beta Kappa, Tau Beta Pi, and Sigma Xi, is not only a distinction of real significance in academic circles, but an asset in one's subsequent professional career.

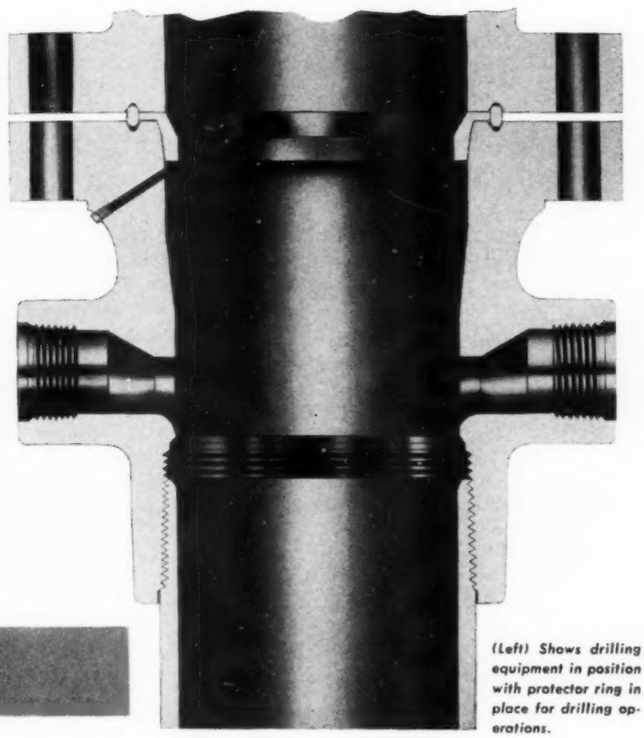
Cost of a College Education

"Another problem that concerns many students planning a college course is that of meeting the personal maintenance and other expenses involved. A large percentage of the students who enter college do not have resources or access to funds adequate to assure proper support for four years of uninterrupted work. All honor to the young man who has the ambition, the courage, and practical ability to 'work his way' through college, or earn for himself a substantial part of his expenses during this period. Many employers prefer to hire young college graduates who have had this experience because of the additional practical knowledge of industry that they have gained by so doing. Certainly, such students have a better appreciation of the value of a college education and of the purchasing value of money. They know how to 'rustle a job' and have a practical understanding of industry and its ways.

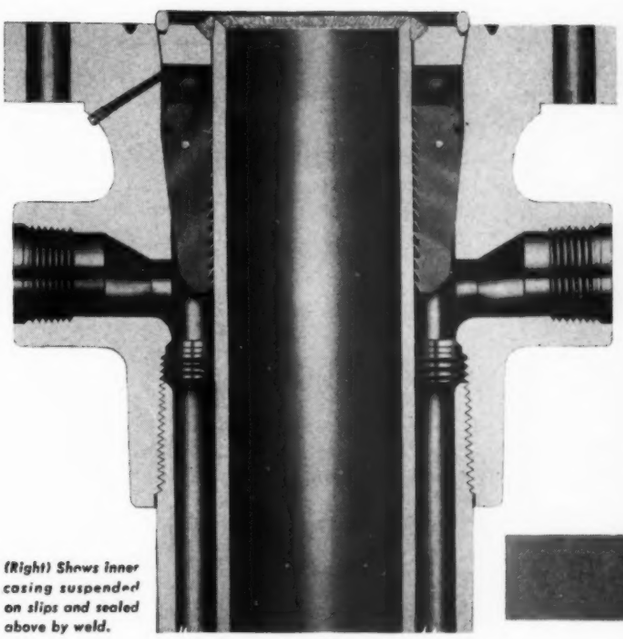
"Nevertheless, most educators agree that it is a mistake for a young man to devote more than a small part of his time to money-earning activities while attending college. A four-year engineering course is a full-time job for any student. If he is to do acceptable work he must usually spend from 48 to 60 hours per week in attending classes and in preparation. This leaves but little time for other work. If circumstances require that he must devote a part of his time to money-earning activities, he should be ready to reduce his academic program proportionately. This results in irregularity in program and extends the time of completion of the curriculum over more

The RHX RECTORHEAD

For Safer Installation with Higher Pressure Units



(Left) Shows drilling equipment in position with protector ring in place for drilling operations.



(Right) Shows inner casing suspended on slips and sealed above by weld.

A *New* Improvement added to an already widely Proved Casing Head

THE new RHX RECTORHEAD embodies all the advantages of the well known RH Slip Suspension RECTORHEAD, yet goes even further in providing positive, safe, economical well control.

Its simplified design and easy installation are made possible by Rector's *exclusive* patented pressure sealing and casing hold-down seal ring. It permits use of a higher pressure tubing head, flanged direct. For example, a 6000 lb. RHX RECTORHEAD, with 900 series flange, may be set and used during drilling operations, with the blowout preventer flanged direct. After oil string is set, a 10,000 lb. test tubing head, with 900 series flange on bottom end may be flanged directly to the RHX RECTORHEAD, using the restricted ring groove. By exposing less area to pressure than the standard ring groove for that particular flange size and series, the restricted ring groove permits the tubing to be tested and used at the next higher pressure rating.

There is a Rector Casing Head, Rector Tubing Head or a Rector Assembled and Tested Christmas Tree to meet every drilling, completion and production requirement.

In addition to this new feature, the RHX RECTORHEAD is fitted with a protector ring used during drilling operations. This ring, as shown in the illustration above, guards the inner groove from damage by bit or kelly. This ring has the same bore as pipe below, and the lip between the flanges does not interfere with the outer API Seal Ring. After drilling operations, the ring may be quickly and easily removed. If a weld test is desired, a pressure sealing pack-off is inserted between slips and welding ring, and test pressure applied through the port in the side of the head directly against weld.

It is the safest, most economical means of well completion. By flanging the heads together direct, intermediate flanges and special bolts are eliminated, meaning less material, and therefore less cost involved.

See the complete line of RECTORHEAD Casing Heads and Tubing Heads in the 1942 Composite Catalog. Or better, call your Rector representative for full details.

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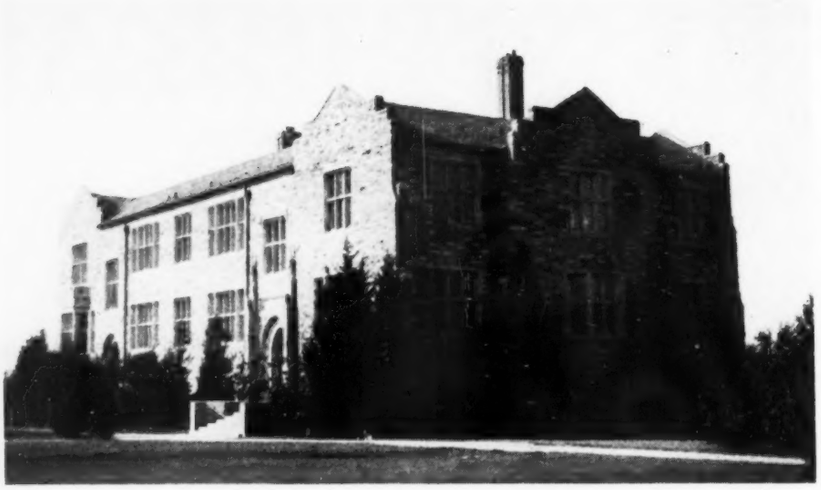


Engineering Building, University of Tulsa

than the usual four-year period. Perhaps this is not altogether objectionable, yet it would undoubtedly be better for the student to be free of the worry and distraction that results from attempting to serve divided interests. If the student must be entirely or partially self-supporting, it is probably preferable in most cases, to do one thing at a time. Work at a job for a time to put aside enough money to allow attendance at college with full time concentration on studies. When funds are exhausted, obtain a leave of absence from college and return to the job for another period of accumulation of savings. College vacation periods, usually aggregating nearly four months per year, afford sufficient opportunity for recouping funds for many students who need be only partially self-supporting.

"Certainly the student entering upon his Freshman year in college, should have available sufficient funds to meet his expenses during this first year. This is a critical period for most students and many who are disqualified for failure to meet scholarship standards can trace their difficulties to an excessive amount of time spent at 'outside work'. After the student has 'found himself' during a successful Freshman year in college, he may apportion his time between academic work and money-earning activities with a better understanding of the college requirements and his own limitations.

"For the superior student, there are often scholarships and loan funds available to assist in meeting the needs of later years. Most universities and colleges are able to employ some students in routine tasks in libraries, laboratories, offices, grounds and buildings maintenance, and advanced students are sometimes employed as assistants to faculty members in the conduct of courses. Often the community in which the college is situated is able to offer many students part-time domestic or other employment, perhaps in return for board and lodging. Industrial and commercial enterprises in the locality may make use of part-time services of student help. The college usually conducts an employment service to assist students in finding remunerative employment. Employment of this character, usually on an hourly basis, at times that will not interfere with the student's courses, will often yield funds with which to defray a substantial part of his living expense; but if too much time is spent in such employment, his scholarship is likely to suffer. Only rarely can the student hope to be entirely self-supporting unless he is willing to live frugally and in this event, he should not expect to carry a full academic program. During recent years, the National Youth Administration has paid deserving students lacking sufficient funds to maintain themselves in college, sums ranging up to $28 per month, in return for time devoted to special work projects conducted by the college.

"Many students entering upon a college course wish to know in advance what their expenses are likely to be. This can seldom be stated with certainty for any individual case, because a large part of the total cost will be for food and lodging and these items depend to a great extent upon the personal tastes and requirements of the individual. Living expense varies also in different communities and in different sections of the country. Food and lodging may be had for as little as $20 per month in some of the frugally managed student coöperative houses, and will seldom exceed $75 per month. Other personal expenses, including recreation, laundry, clothing, etc., also vary widely depending upon habits and social activity of the individual, but this item need not be greatly different from what he has been accustomed to spending in his home community, and can be closely estimated. Other major items of expense are those assessed by the college for tuition, laboratory, registration, library, gymnasium, hospital, and other fees. Tuition fees as high as $600 per year are assessed by some colleges when a large part of the operating revenue must be obtained from this source. On the other hand, some of the state-supported universities and colleges make no charge for tuition, except perhaps to non-resident students from other states and countries. Most colleges require all students to pay a fee of something like $10 to $30 per year in return for hospital, gymnasium, and library privileges, and the student should allow $5 to $20 per year for payment of student organization memberships, subscriptions to college publications, and participation in extra-curricular student activities. Laboratory fees are usually in amount sufficient only to repay the cost of materials and equipment actually consumed by the student, and will naturally vary with the character of the course. Such fees may range from a few dollars to $25 or even more per course, in extreme cases. Seldom, however, will the student be enrolled in more than two or three laboratory or field courses requiring fees, during any one semester. The College of Engineering of the University of California has learned, as a result of long experience, that the cost of all laboratory fees for the average engineering student, is about $25 per half year. The aggregate of all these expenditures, exclusive of tuition fees, when assessed, will range from as little as $400 per year to more than $1000 per year, depending chiefly upon the student's personal requirements. It should be understood that these estimates are for an eight-month period, the usual time spent in the academic routine during each year. It is assumed that the student will be at home or engaged in other activities during the remainder of each year. Nearly every college publishes in its 'catalog', estimates of students' expense, based on conditions obtaining in the particular locality in which the college is situated.

"By the way, have you decided which college or university is to be your Alma Mater? Your choice might be any one of at least 20 different institutions, each of which offers a curriculum in petroleum engineering and has advantages worth considering. I've visited nearly all lately. Call another day when we have more time and we'll talk about them."

——☆☆☆——

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 57

THE tables on the following pages are designed to save time and effort for the technician, and to assist the practical field or plant worker to solve problems commonly encountered in routine work. They are not intended nor expected to supplant technical training and make every man his own designer. Most of the tables can be understood and applied by anyone acquainted with the simple fundamentals of mathematics.

For the convenience of readers who wish to refer to the tables, each page carries in the upper right corner an index number that classifies the table according to subject matter.

All petroleum engineering literature may be indexed for reference according to the Dewey Decimal System as modified and extended for the petroleum industry by L. C. Uren, professor of petroleum engineering at the University of California. When classified according to these index numbers the material follows in a logical sequence and falls into several natural divisions, as illustrated by the following outline:

Nos. P000-P399—General
Nos. P400-P499—Drilling
Nos. P500-P599—Production
Nos. P600-P699—Transportation and Storage (includes Pipe Line)
Nos. P700-P799—Refining, including
Nos. P770-P799—Natural Gasoline, which may be classifed in a separate division (as shown here) if of special interest to the user

To aid the reader in using the Decimal System, a subject index arranged alphabetically has been published, and is available at a cost of 50 cents per copy from *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

INDEX TO TABLES*

Title of Table	*Index No.*	*Page*	*Issue*
Squares of whole numbers	P 061.001.1	131	Nov.
Squares of whole numbers	P 061.001.2	119	Feb.
Square roots of whole numbers	P 061.002.1	119	Dec.
Cube roots of whole numbers	P 061.003.1	109	Dec.
Conversion tables—Foreign weight units (sheet 1)	P 066.002.	101	Jan.
Conversion tables—Foreign weight units (sheet 2)	P 066.002.	117	Feb.
Conversion tables—Foreign volume units	P 066.003.	105	Jan.
Heating, dressing, and hardening cable-tool drilling bits	P 424.221.	215	Oct.
Conversion table for mud weights	P 425.218.41	125	Feb.
Weight of dry material added to drilling mud lb. per gal. Sp. Gr. of additive 2.70	P 425.218.43	179	Mar.
Drilled hole survey data (sheet 1)	P 429.200.1	171	Mar.
Wall surface area and volume of reamed hole	P 434.000.	129	Feb.
Weight of dry material added to drilling mud, lb. per gal. (Sp. Gr. of additive 2.35)	P 444.200.	113	Dec.
Weight of dry material added to drilling mud, lb. per gal. (Sp. G. of additive 2.50)	P 444.201.	107	Jan.
Theoretical volume of gravel required around liners in cu. ft. per ft. of length	P 459.300.	117	Dec.
Rise in fluid level, etc., due to running 1½-in. non-upset tubing in well fluid	P 511.141.150.2	91	July
Rise in fluid level, etc., due to running 2-in. non-upset tubing in well fluid	P 511.141.202.	105	Sept.
Rise in fluid level, etc., due to running 2½-in. external-upset tubing in well fluid	P 511.141.250.1	89	Aug.
Rise in fluid level, etc., due to running 2½-in. non-upset tubing in well fluid	P 511.141.252.	107	Sept.
Rise in fluid level, etc., due to running 3-in. external-upset tubing in well fluid	P 511.141.301.	219	Oct.
Rise in fluid level, etc., due to running 3-in. non-upset tubing in well fluid	P 511.141.302.	213	Oct
Rise in fluid level, etc., due to running 3½-in. external upset tubing in well fluid	P 511.141.351.	133	Nov.
Rise in fluid level, etc., due to running 3½-in. non-upset tubing in well fluid	P 511.141.352.	115	Dec.
Rise in fluid level, etc., due to running 4-in. external-upset tubing in well fluid	P 511.141.401.	111	Jan.
Rise in fluid level, etc., due to running 4-in. non-upset tubing in well fluid	P 511.141.402.	169	Mar.
Velocity of flow, ft. per sec., through annulus between 1¼-in. and 4-in. tubing (sheet 5B)	P 533.300.125.2	87	Aug.

Title of Table		Index No.	Page	Issue
Velocity of flow, ft. per sec., through annulus between 1½-in. and 4-in. tubing		P 533.300.150.2	89	July
Velocity of flow, ft. per sec., through annulus between 2-in. and 3½-in. tubing	(sheet 1B)	P 533.300.200.2	103	Sept.
Velocity of flow, ft. per sec., through annulus between 2-in. and 4-in. tubing	(sheet 2A)	P 533.300.200.2	115	Sept.
Velocity of flow, ft. per sec., through annulus between 2-in. and 4-in. tubing	(sheet 2B)	P 533.300.200.2	127	Nov.
Velocity of flow, ft. per sec., through annulus between 2½-in. and 4-in. tubing	(sheet 1B)	P 533.300.250.2	207	Oct.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.150.1	173	Mar.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.200.1	127	Feb.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.250.1	103	Jan.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.300.1	211	Oct.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.301.	87	July
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.350.1	91	Aug.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.351.	111	Sept.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.400.1	109	Sept.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.401.	209	Oct.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.450.1	137	Nov.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.451.	125	Nov.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.50	129	Nov.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.500.1	175	Mar.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.501.	107	Dec.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.55	111	Dec.
Gravity of dry oil in oil-water mixtures, deg. A.P.I.		P 677.410.551.	99	Jan.
Base temperature multipliers, 60 deg. F. Abs.		P 680.1	123	Feb.
Pressure extensions—orifice meter calculations	(sheet 10)	P 683.32	113	Sept.
Pressure extensions—orifice meter calculations	(sheet 11)	P 683.32	217	Oct.
Pressure extensions—orifice meter calculations	(sheet 12)	P 683.32	109	Jan.
Pressure extensions—orifice meter calculations	(sheet 13)	P 683.32	121	Feb.
Pressure extensions—orifice meter calculations	(sheet 14)	P 683.32	177	Mar.
Static pressures, lb. per sq. in. abs., corresponding to L-10 chart readings		P 683.33	135	Nov.
Saponification numbers—oils containing more than 30% fatty oils—Method A	(sheet 7)	P 747.501.11	181	Mar.

*This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue, and 37-48, inclusive, in the June, 1941, issue.

INDEX TO ADVERTISERS IN TABLES

		Page	Issue	Backing Table No.
Air Reduction Company, Inc.		112	Sept.	P 677.410.351.
Air Reduction Company, Inc.		112	Dec.	P 677.410.55
American Air Filter Co., Inc.		136	Nov.	P 683.33
American Air Filter Co., Inc.		106	Jan.	P 066.003.
American Meter Company	(sheet 11)	218	Oct.	P 683.32
American Steel & Wire Company		214	Oct.	P 511.141.302.
American Steel & Wire Company		114	Dec.	P 444.200.
Bantam Bearings Corporation		88	July	P 677.410.301.
Bantam Bearings Corporation		92	Aug.	P 677.410.350.1
Bantam Bearings Corporation	(sheet 1B)	104	Sept.	P 533.300.200.2
Bantam Bearings Corporation		220	Oct.	P 511.141.301.
Bantam Bearings Corporation	(sheet 2B)	128	Nov.	P 533.300.200.2
Bantam Bearings Corporation		120	Dec.	P 061.002.1
Bantam Bearings Corporation		100	Jan.	P 677.410.551.
Bantam Bearings Corporation		130	Feb.	P 434.000.
Bantam Bearings Corporation		170	Mar.	P 511.141.402.
Bethlehem Steel Company	(sheet 3B)	90	July	P 533.300.150.2
Chapman Valve Manufacturing Company, The	(sheet 10)	114	Sept.	P 683.32
Chapman Valve Manufacturing Company, The		212	Oct.	P 677.410.300.1
Chapman Valve Manufacturing Company, The		116	Dec.	P 511.141.352.
Chapman Valve Manufacturing Company, The		108	Jan.	P 444.201.
Cook, C. Lee, Manufacturing Co., Inc.		176	Mar.	P 677.410.500.1
Crane Co.		128	Feb.	P 677.410.200.1
Foxboro Company, The	(sheet 13)	122	Feb.	P 683.32
Hazard Wire Rope Division of American Chain and Cable Co., Inc.		126	Nov.	P 677.410.451.
Hazard Wire Rope Division of American Chain and Cable Co., Inc.		126	Feb.	P 425.218.41
Hyatt Bearings Division, General Motors Sales Corporation		92	July	P 511.141.150.2
Hyatt Bearings Division, General Motors Sales Corporation		88	Aug.	P 533.300.125.2
Hyatt Bearings Division, General Motors Sales Corporation	(sheet 2A)	116	Sept.	P 533.300.200.2
Hyatt Bearings Division, General Motors Sales Corporation	(sheet 1B)	208	Oct.	P 533.300.250.2
Hyatt Bearings Division, General Motors Sales Corporation		138	Nov.	P 677.410.450.1
Hyatt Bearings Division, General Motors Sales Corporation		108	Dec.	P 677.410.501.
Hyatt Bearings Division, General Motors Sales Corporation		112	Jan.	P 511.141.401.
Hyatt Bearings Division, General Motors Sales Corporation	(sheet 2)	118	Feb.	P 066.002.
Hyatt Bearings Division, General Motors Sales Corporation	(sheet 7)	182	Mar.	P 747.501.11
LeRoi Company		106	Sept.	P 511.141.202.
LeRoi Company		132	Nov.	P 061.001.1
LeRoi Company	(sheet 1)	102	Jan.	P 066.002.
LeRoi Company		174	Mar.	P 677.410.150.1
Lincoln Electric Company		130	Nov.	P 674.410.50
Medart Company, The		110	Sept.	P 677.410.400.1
Medart Company, The		110	Dec.	P 061.003.1
National Carbon Company, Inc.		124	Feb.	P 680.1
Reed Roller Bit Company		90	Aug.	P 511.141.250.1
Ridge Tool Company, The		120	Feb.	P 061.001.2
Skinner, M. B. Co.		210	Oct.	P 677.410.401.
Spang & Company		216	Oct.	P 424.221.
Staynew Filter Corp.	(sheet 14)	178	Mar.	P 683.32
Texaco Development Corp.		118	Dec.	P 459.300.
Vortox Manufacturing Company	(sheet 12)	110	Jan.	P 683.32
Waukesha Motor Company	(sheet 1)	172	Mar.	P 429.200.1
Whitney Chain & Manufacturing Company		108	Sept.	P 511.141.252.
Whitney Chain & Manufacturing Company		134	Nov.	P 511.141.351.
Whitney Chain & Manufacturing Company		104	Jan.	P 677.410.250.1
Whitney Chain & Manufacturing Company		180	Mar.	P 425.218.43

RISE IN FLUID LEVEL, ETC., DUE TO RUNNING 4-IN. NON-UPSET TUBING IN WELL FLUID

Diameter of outer string or open hole, in.	Internal diameter of outer string or open hole, in.	Volume[1] contained in outer string or open hole		Volume[1] contained in annular space		Volume[1] in well bore when tubing is in hole (volume in annulus plus volume in tubing)		For every 100 ft. of tubing run in fluid, fluid level will be raised:	
		gal.	bbl.	gal.	bbl.	gal.	bbl.	in annular space when lower end of tubing is closed, ft.-in.	in well bore when lower end of tubing is open, ft.-in.
Casing strings[2]									
6⅝	6.135	153.6	3.657	70.57	1.680	134.5	3.202	118- 1	14- 3
6⅝	5.675	131.4	3.129	48.07	1.145	112.0	2.667	173- 4	8-11
7	6.538	174.4	4.152	91.07	2.168	155.0	3.690	91- 6	12- 4
7	5.920	143.0	3.405	59.67	1.421	123.6	2.943	139- 8	15- 6
7⅝	7.125	207.1	4.931	123.8	2.948	187.7	4.469	67- 4	10- 2
7⅝	6.625	179.1	4.624	95.77	2.280	159.7	3.802	87- 0	12- 0
8⅝	8.097	267.5	6.369	184.2	4.386	248.1	5.907	45- 3	7- 9
8⅝	7.511	230.2	5.481	146.9	3.498	210.8	5.019	56- 9	9- 1
9⅝	9.063	335.1	7.979	251.8	5.995	315.7	7.517	33- 0	6- 1
9⅝	8.535	297.2	7.076	213.9	5.093	277.8	6.614	38-11	6-11
10¾	10.192	423.8	10.09	340.5	8.107	404.4	9.629	24- 6	4- 9
10¾	9.760	388.7	9.255	305.4	7.271	369.3	8.793	27- 3	5- 2
11¾	11.150	507.2	12.08	423.9	10.093	487.8	11.614	19- 8	3-11
11¾	10.772	473.4	11.27	390.1	9.288	454.0	10.810	21- 4	4- 3
13⅜	12.715	659.6	15.71	576.3	13.721	640.2	15.243	14- 6	3- 0
13⅜	12.347	622.0	14.81	538.7	12.826	602.6	14.348	15- 6	3- 2
Open hole (bit size)[3]									
6	6.000	146.9	3.498	63.57	1.514	127.5	3.036	131- 1	15- 0
6⅛	6.125	153.1	3.645	69.77	1.661	133.7	3.183	119- 5	14- 4
6½	6.500	172.4	4.105	99.07	2.359	163.0	3.881	84- 1	11- 9
6¾	6.750	185.9	4.423	102.6	2.443	166.5	3.964	81- 3	11- 6
7	7.000	199.9	4.760	116.6	2.776	180.5	4.298	71- 6	10- 7
7½[4]	7.500	229.5	5.464	146.2	3.481	210.1	5.002	57- 0	9- 1
7¾[4]	7.750	245.1	5.836	161.8	3.852	225.7	5.374	51- 6	8- 6
8¼[4]	8.500	294.8	7.019	211.5	5.036	275.4	6.557	39- 5	6-11
9¾[4]	9.750	387.9	9.236	304.6	7.252	368.5	8.774	27- 4	5- 2
10⅝	10.625	460.6	10.97	377.3	8.983	441.2	10.505	22- 1	4- 4

The 4-in. non-upset tubing has a calculated weight of 12.53 lb. per ft. (including a coupling spaced every 20 ft.). The volume displaced by 100 ft. of tubing and 5 couplings: (1) by the steel itself (with lower end of tubing open), 19.147 gal. or 0.4559 bbl.; (2) by the pipe (with lower end of tubing closed), 83.327 gal. or 1.9840 bbl. The volume contained within 100 ft. of the tubing is 63.917 gal. or 1.5218 bbl.

[1]All volume figures are based on 100 ft. of depth; multiply to convert to other depths or lengths. For example, if the depth or length is 5196 ft., multiply by 51.96.

[2]Only maximum and minimum weights of pipe are shown for each casing size.

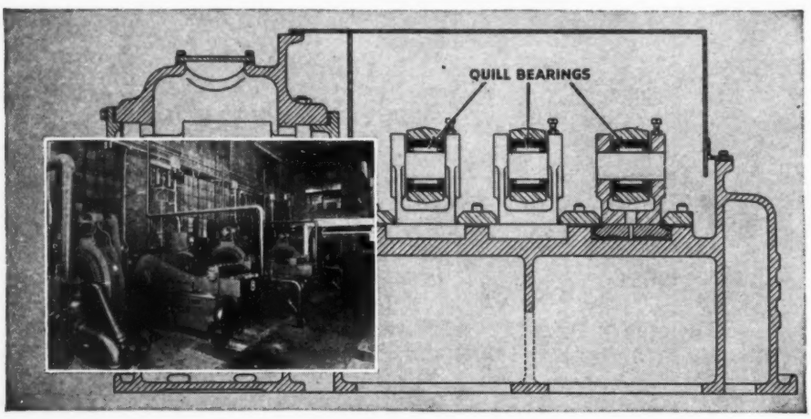
[3]Variation in diameter of open hole due to caving, etc., is disregarded.

[4]This diameter is an average of the two bit sizes ⅛ in. larger and smaller, respectively.

Table suggested by George B. Rice, Butler & Horne Drilling Co., Dallas, Texas.

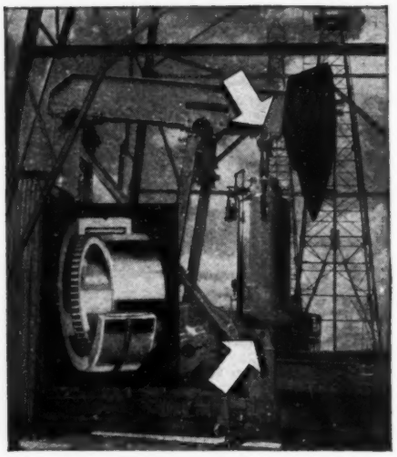
IN THE NEWS
WITH BANTAM BEARINGS

3-INCH ANTI-AIRCRAFT GUNS are true precision machines that must operate with extreme accuracy and complete dependability. In the design and construction of many of America's new weapons, the skill and experience of Bantam engineers are playing an important part. Bantam's broad background in the design and application of every major type of anti-friction bearing aids in the solution of new and unusual bearing problems.

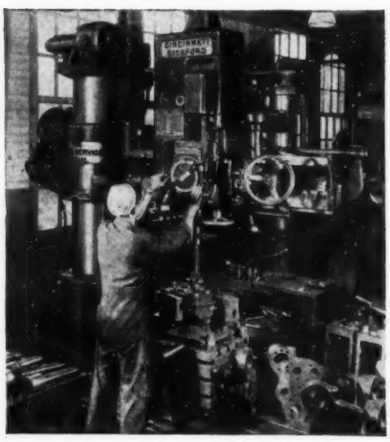


LONG, DEPENDABLE LIFE is essential in this application of Bantam Quill Bearings on the wrist pins of Baldwin Southwark Triplex Pumps. The pumps, shown in inset, are used to furnish high-pressure water for a large shell-forging plant, and deliver 450 gallons per minute at a working pressure of 1,500 pounds per square inch. Load application ranges from zero to maximum 95 times a minute. The Quill Bearings help keep maintenance costs down in this exacting service. For further information on this compact, high-capacity bearing, write for Bulletin P-104.

BANTAM'S ENGINEERING COOPERATION is especially valuable in meeting new and unusual requirements. Bantam makes every major type of anti-friction bearing—straight roller, tapered roller, needle, and ball. Bantam engineers aid in the selection of the type that best suits your application—or design special bearings in sizes and types that meet out-of-the-ordinary service requirements. If you have a difficult bearing problem, TURN TO BANTAM.



IN THE NATION'S OIL FIELDS, pumping units are working 'round the clock to meet wartime needs for this vital fluid. Leading manufacturers of pumpers have found that Bantam Quill Bearings contribute to efficient operation, reduce need for maintenance attention. Arrows on photograph show location of Quill Bearings on The Parkersburg Rig & Reel Company's 66-HK pumping unit—an application typical of the many oil field uses for the Quill Bearing.



MACHINE TOOLS THAT MAKE MACHINE TOOLS take on new importance in speeding the nation's wartime production. These Super Service Radials built by The Cincinnati Bickford Tool Co. are working 24 hours a day, 7 days a week, helping to turn out turret lathes. Bantam Quill Bearings in these machines facilitate travel of the head along the arm—another instance of the adaptability of these compact bearings.

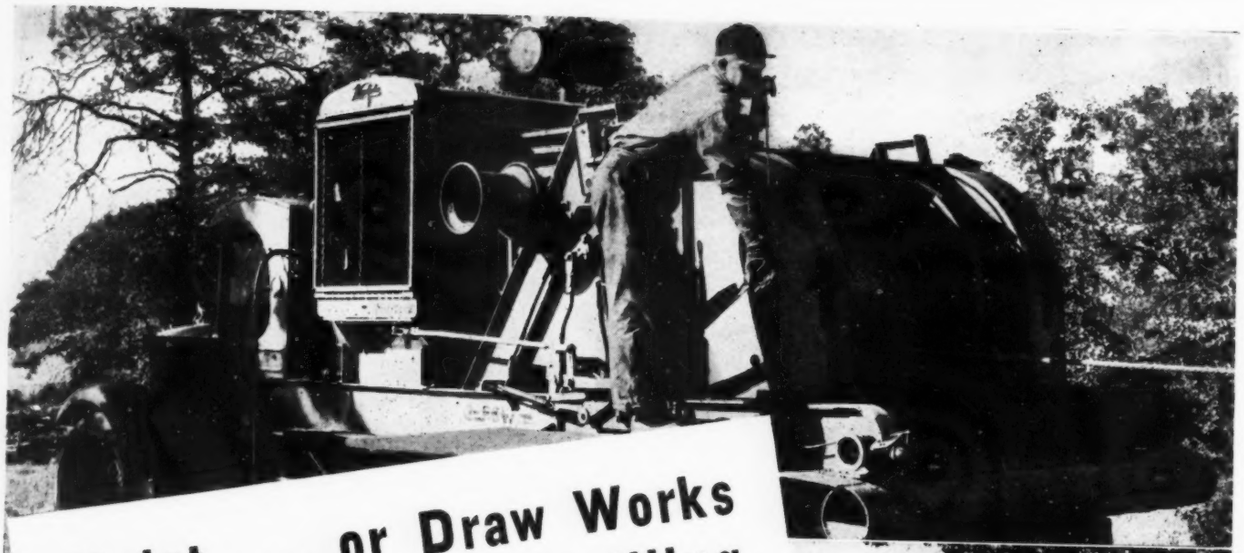
BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

DRILLED HOLE SURVEY DATA PER 100 FT. OF DEPTH

Deg. of drift from vertical	Horizontal drift in ft.	Depth loss in ft.	True depth of hole in ft.	Deg. of drift from vertical	Horizontal drift in ft.	Depth loss in ft.	True depth of hole in ft.
				16°	27.56	3.87	96.13
0° 15′	0.44	0.00	100.00	16° 15′	27.98	3.99	96.01
0° 30′	0.87	0.00	100.00	16° 30′	28.40	4.12	95.88
0° 45′	1.31	0.01	99.99	16° 45′	28.82	4.24	95.76
1°	1.75	0.01	99.99	17°	29.24	4.37	95.63
1° 15′	2.18	0.02	99.98	17° 15′	29.65	4.50	95.50
1° 30′	2.62	0.03	99.97	17° 30′	30.07	4.63	95.37
1° 45′	3.05	0.05	99.95	17° 45′	30.49	4.76	95.24
2°	3.49	0.06	99.94	18°	30.90	4.89	95.11
2° 15′	3.93	0.08	99.92	18° 15′	31.32	5.03	94.97
2° 30′	4.36	0.09	99.91	18° 30′	31.73	5.17	94.83
2° 45′	4.80	0.11	99.89	18° 45′	32.14	5.31	94.69
3°	5.23	0.14	99.86	19°	32.56	5.45	94.55
3° 15′	5.67	0.16	99.84	19° 15′	32.96	5.59	94.41
3° 30′	6.11	0.19	99.81	19° 30′	33.38	5.74	94.26
3° 45′	6.54	0.21	99.79	19° 45′	33.79	5.88	94.12
4°	6.98	0.24	99.76	20°	34.20	6.03	93.97
4° 15′	7.41	0.27	99.73	20° 15′	34.61	6.18	93.82
4° 30′	7.85	0.31	99.69	20° 30′	35.02	6.33	93.67
4° 45′	8.28	0.34	99.66	20° 45′	35.43	6.49	93.51
5°	8.72	0.38	99.62	21°	35.84	6.64	93.36
5° 15′	9.15	0.42	99.58	21° 15′	36.24	6.80	93.20
5° 30′	9.95	0.46	99.54	21° 30′	36.65	6.96	93.04
5° 45′	10.02	0.50	99.50	21° 45′	37.06	7.12	92.88
6°	10.45	0.55	99.45	22°	37.46	7.28	92.72
6° 15′	10.89	0.59	99.41	22° 15′	37.87	7.45	92.55
6° 30′	11.32	0.64	99.36	22° 30′	38.27	7.61	92.39
6° 45′	11.75	0.69	99.31	22° 45′	38.67	7.78	92.22
7°	12.19	0.75	99.25	23°	39.07	7.95	92.05
7° 15′	12.62	0.80	99.20	23° 15′	39.47	8.12	91.88
7° 30′	13.05	0.86	99.14	23° 30′	39.88	8.29	91.71
7° 45′	13.49	0.91	99.09	23° 45′	40.28	8.47	91.53
8°	13.92	0.97	99.03	24°	40.67	8.65	91.35
8° 15′	14.35	1.03	98.97	24° 15′	41.07	8.82	91.18
8° 30′	14.78	1.10	98.90	24° 30′	41.47	9.00	91.00
8° 45′	15.21	1.16	98.84	24° 45′	41.87	9.19	90.81
9°	15.64	1.23	98.77	25°	42.26	9.37	90.63
9° 15′	16.07	1.30	98.70	25° 15′	42.66	9.55	90.45
9° 30′	16.50	1.37	98.63	25° 30′	43.05	9.74	90.26
9° 45′	16.93	1.44	98.56	25° 45′	43.45	9.93	90.07
10°	17.36	1.52	98.48	26°	43.84	10.12	89.88
10° 15′	17.79	1.60	98.40	26° 15′	44.23	10.31	89.69
10° 30′	18.22	1.67	98.33	26° 30′	44.62	10.51	89.49
10° 45′	18.65	1.75	98.25	26° 45′	45.01	10.70	89.30
11°	19.08	1.84	98.16	27°	45.40	10.90	89.10
11° 15′	19.51	1.92	98.08	27° 15′	45.79	11.10	88.90
11° 30′	19.94	2.01	97.99	27° 30′	46.18	11.30	88.70
11° 45′	20.36	2.09	97.91	27° 45′	46.56	11.50	88.50
12°	20.79	2.19	97.81	28°	46.95	11.71	88.29
12° 15′	21.22	2.27	97.72	28° 15′	47.33	11.91	88.09
12° 30′	21.64	2.37	97.63	28° 30′	47.72	12.12	87.88
12° 45′	22.07	2.47	97.53	28° 45′	48.10	12.33	87.67
13°	22.50	2.56	97.44	29°	48.48	12.54	87.46
13° 15′	22.92	2.66	97.34	29° 15′	48.86	12.75	87.25
13° 30′	23.35	2.76	97.24	29° 30′	49.24	12.96	87.04
13° 45′	23.77	2.87	97.13	29° 45′	49.62	13.18	86.82
14°	24.19	2.97	97.03	30°	50.00	13.40	86.60
14° 15′	24.62	3.08	96.92	30° 15′	50.38	13.62	86.38
14° 30′	25.04	3.18	96.82	30° 30′	50.75	13.84	86.16
14° 45′	25.46	3.29	96.71	30° 45′	51.13	14.06	85.94
15°	25.88	3.41	96.59	31°	51.50	14.28	85.72
15° 15′	26.30	3.52	96.48	31° 15′	51.88	14.51	85.49
15° 30′	26.72	3.64	96.36	31° 30′	52.25	14.74	85.26
15° 45′	27.14	3.75	96.25	31° 45′	52.62	14.96	85.04

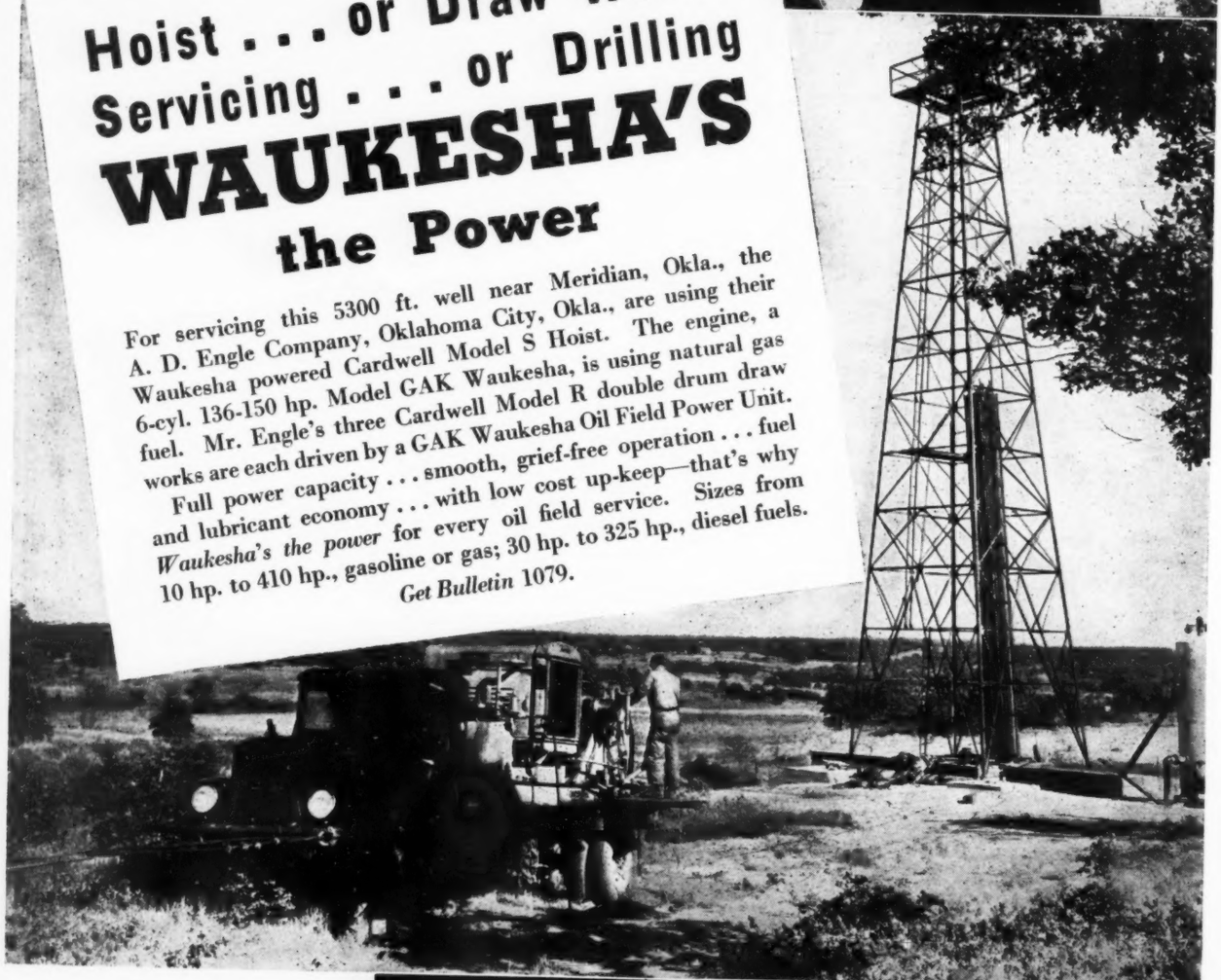


Hoist . . . or Draw Works
Servicing . . . or Drilling
WAUKESHA'S
the Power

For servicing this 5300 ft. well near Meridian, Okla., the A. D. Engle Company, Oklahoma City, Okla., are using their Waukesha powered Cardwell Model S Hoist. The engine, a 6-cyl. 136-150 hp. Model GAK Waukesha, is using natural gas fuel. Mr. Engle's three Cardwell Model R double drum draw works are each driven by a GAK Waukesha Oil Field Power Unit.

Full power capacity . . . smooth, grief-free operation . . . fuel and lubricant economy . . . with low cost up-keep—that's why *Waukesha's the power* for every oil field service. Sizes from 10 hp. to 410 hp., gasoline or gas; 30 hp. to 325 hp., diesel fuels.

Get Bulletin 1079.



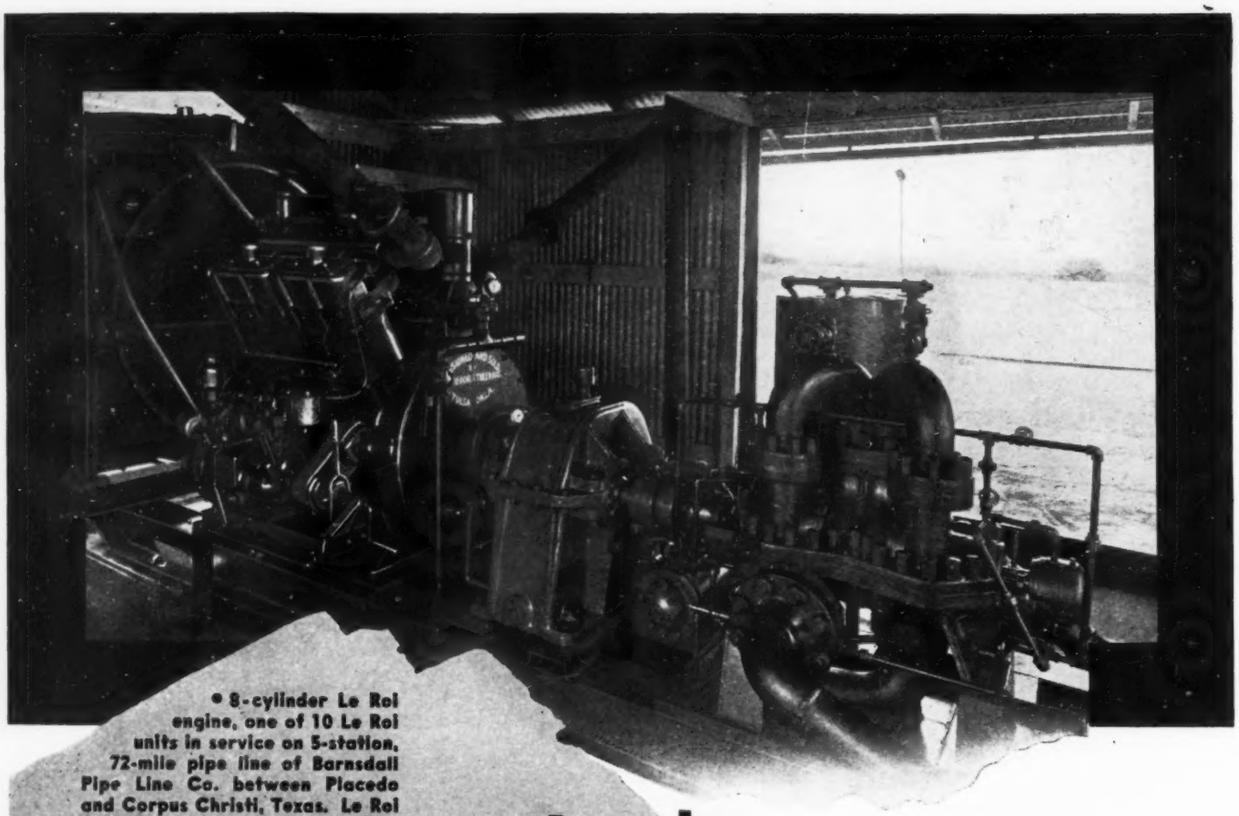
WAUKESHA MOTOR COMPANY
WAUKESHA, WISCONSIN
NEW YORK TULSA
LOS ANGELES

WAUKESHA
Oil Field ENGINES

GRAVITY OF DRY OIL IN OIL-WATER MIXTURES, DEG. A.P.I.

Gravity of "wet" oil deg. A.P.I.	Percent water in mixture									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
15.0	**15.00**	15.01	15.01	15.02	15.03	15.03	15.03	15.04	15.04	15.05
.1	15.11	15.11	15.12	15.12	15.13	15.13	15.14	15.14	15.15	15.16
.2	15.20	15.20	15.21	15.21	15.23	15.23	15.23	15.24	15.24	15.25
.3	15.30	15.31	15.32	15.32	15.33	15.33	15.34	15.34	15.35	15.36
.4	15.41	15.42	15.42	15.43	15.44	15.44	15.45	15.45	15.46	15.46
15.5	15.50	15.51	15.51	15.52	15.53	15.53	15.54	15.54	15.55	15.56
.6	15.61	15.62	15.62	15.63	15.64	15.64	15.65	15.65	15.66	15.66
.7	15.70	15.71	15.71	15.72	15.73	15.73	15.74	15.74	15.75	15.76
.8	15.81	15.82	15.82	15.83	15.84	15.84	15.85	15.85	15.86	15.86
.9	15.90	15.91	15.91	15.92	15.93	15.93	15.94	15.95	15.95	15.96
16.0	16.01	16.02	16.02	16.03	16.04	16.04	16.05	16.05	16.06	16.07
.1	16.10	16.11	16.11	16.12	16.13	16.13	16.14	16.15	16.15	16.16
.2	16.21	16.22	16.22	16.23	16.24	16.24	16.24	16.26	16.26	16.27
.3	16.30	16.31	16.32	16.32	16.33	16.34	16.34	16.35	16.36	16.36
.4	16.41	16.42	16.42	16.43	16.44	16.44	16.45	16.46	16.47	16.47
16.5	16.50	16.51	16.52	16.52	16.54	16.54	16.54	16.55	16.56	16.57
.6	16.61	16.62	16.63	16.63	16.65	16.65	16.65	16.66	16.67	16.68
.7	16.71	16.71	16.72	16.73	16.74	16.74	16.75	16.76	16.76	16.77
.8	16.81	16.82	16.83	16.84	16.85	16.85	16.86	16.86	16.87	16.88
.9	16.91	16.92	16.92	16.93	16.94	16.94	16.95	16.96	16.97	16.97
17.0	**17.00**	17.01	17.02	17.02	17.04	17.04	17.05	17.05	17.06	17.07
.1	17.11	17.12	17.13	17.13	17.15	17.15	17.16	17.16	17.17	17.18
.2	17.20	17.21	17.22	17.23	17.24	17.24	17.25	17.26	17.27	17.27
.3	17.31	17.32	17.33	17.34	17.35	17.35	17.36	17.37	17.38	17.38
.4	17.41	17.41	17.42	17.43	17.44	17.45	17.46	17.46	17.47	17.48
17.5	17.50	17.51	17.52	17.53	17.54	17.54	17.55	17.56	17.57	17.57
.6	17.61	17.62	17.63	17.64	17.65	17.65	17.66	17.67	17.68	17.69
.7	17.71	17.71	17.72	17.73	17.74	17.75	17.76	17.76	17.77	17.78
.8	17.80	17.81	17.82	17.83	17.84	17.84	17.85	17.86	17.87	17.88
.9	17.91	17.92	17.93	17.94	17.95	17.95	17.96	17.97	17.98	17.99
18.0	18.01	18.02	18.02	18.03	18.05	18.05	18.06	18.07	18.07	18.08
.1	18.10	18.11	18.12	18.13	18.14	18.14	18.15	18.16	18.17	18.18
.2	18.21	18.22	18.23	18.24	18.25	18.26	18.26	18.27	18.28	18.29
.3	18.31	18.32	18.33	18.33	18.35	18.35	18.36	18.37	18.38	18.39
.4	18.40	18.41	18.42	18.43	18.44	18.45	18.46	18.47	18.47	18.48
18.5	18.51	18.52	18.53	18.54	18.56	18.56	18.57	18.58	18.59	18.60
.6	18.61	18.62	18.63	18.64	18.65	18.66	18.67	18.67	18.68	18.69
.7	18.71	18.71	18.72	18.73	18.75	18.75	18.76	18.77	18.78	18.79
.8	18.80	18.81	18.82	18.83	18.84	18.85	18.86	18.87	18.88	18.89
.9	18.91	18.92	18.93	18.94	18.96	18.96	18.97	18.98	18.99	**19.00**
19.0	19.01	19.02	19.03	19.04	19.05	19.06	19.07	19.08	19.09	19.10
.1	19.11	19.11	19.13	19.13	19.15	19.15	19.16	19.17	19.17	19.19
.2	19.20	19.21	19.22	19.23	19.25	19.25	19.26	19.27	19.28	19.29
.3	19.31	19.32	19.33	19.34	19.36	19.36	19.37	19.38	19.39	19.40
.4	19.41	19.42	19.43	19.44	19.46	19.46	19.47	19.48	19.49	19.50
19.5	19.50	19.52	19.53	19.54	19.55	19.56	19.57	19.58	19.59	19.60
.6	19.60	19.62	19.63	19.63	19.65	19.66	19.67	19.68	19.69	19.70
.7	19.72	19.73	19.74	19.75	19.77	19.77	19.78	19.79	19.80	19.81
.8	19.82	19.83	19.84	19.85	19.86	19.87	19.88	19.89	19.90	19.91
.9	19.91	19.92	19.93	19.94	19.96	19.97	19.98	19.99	**20.00**	20.01

Gravity of dry oil in oil water mixture, deg. A.P.I. with percent water in mixture less than one suggested by R. W. Miller, Phillips Petroleum Company, Oklahoma City, Oklahoma.



• 8-cylinder Le Roi engine, one of 10 Le Roi units in service on 5-station, 72-mile pipe line of Barnsdall Pipe Line Co. between Placedo and Corpus Christi, Texas. Le Roi equipment includes one 6-cylinder, seven 8-cylinder, two 12-cylinder engines. Pumping capacity of the line, 19,000 barrels of oil per day.

Leaders in the industry depend on LE ROI Engines

for economical, low cost pipe line power

When you hook up your pipe line pumps to Le Roi engines, you *know* that you have dependable, money-saving power. Years of satisfactory service, among prominent, successful operators, back up your own good judgment in selecting Le Roi.

You're "low with Le Roi," all along the line — in first cost, installation cost, operating cost, maintenance cost.

Engine and pump can be assembled as a single portable unit. You avoid heavy expense and loss of time in transferring from one station to another whenever necessary.

Le Roi engineering, based on more than a quarter of a century of experience in building heavy duty engines, gives you an extra margin of economy, an extra reserve of power. These overhead valve, in-line or V-type engines are designed to operate at low cost on gasoline, natural gas, or butane.

Equip with Le Roi — get rid of your power troubles, and enjoy long-run satisfaction. Write, stating size of engine in which you are interested, and we will send bulletins giving complete details. P-5

Other Models 4 to 400 H.P.

4 to 100 H.P. for gathering and pick-up pumps.

100 to 400 H.P. sizes for main line, standby, or emergency service — capable of handling 12,000 to 35,000 bbls. per day.

★

HIGH dependability — Rugged construction, deep crankcase, special costly alloys, exceptional precision in manufacture, thorough testing. Quick-acting gasoline starting engines and dual ignition on larger sizes.

LE ROI COMPANY • MILWAUKEE, WIS. • TULSA, OKLA.

Southern Engine & Pump Company
Houston — Dallas — Kilgore, Texas

General Machine & Supply Company
Wichita Falls — Odessa, Texas

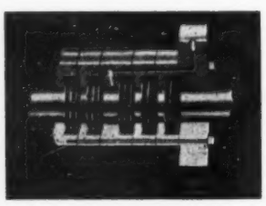
Western Machinery Company
St. Louis, Missouri • Salem, Illinois

GRAVITY OF DRY OIL IN OIL-WATER MIXTURES, DEG. A.P.I.

Gravity of "wet" oil, deg. A.P.I.	Percent water in mixture									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
50.0	50.05	50.11	50.16	50.21	50.27	50.31	50.37	50.42	50.47	50.52
.1	50.15	50.20	50.25	50.30	50.36	50.41	50.46	50.51	50.57	50.62
.2	50.24	50.29	50.35	50.40	50.46	50.50	50.55	50.61	50.66	50.71
.3	50.36	50.41	50.46	50.51	50.57	50.62	50.67	50.73	50.78	50.83
.4	50.45	50.50	50.56	50.61	50.67	50.71	50.76	50.82	50.87	50.93
50.5	50.55	50.60	50.65	50.70	50.76	50.81	50.86	50.91	50.97	51.02
.6	50.66	50.72	50.77	50.82	50.88	50.93	50.98	51.03	51.09	51.14
.7	50.76	50.81	50.86	50.92	50.97	51.02	51.07	51.13	51.18	51.24
.8	50.85	50.90	50.96	51.01	51.07	51.12	51.17	51.22	51.28	51.33
.9	50.95	**51.00**	51.05	51.10	51.16	51.21	51.26	51.32	51.37	51.43
51.0	51.06	51.12	51.17	51.22	51.28	51.33	51.38	51.44	51.49	51.55
.1	51.16	51.21	51.26	51.32	51.38	51.42	51.48	51.53	51.59	51.64
.2	51.25	51.31	51.36	51.41	51.47	51.52	51.57	51.63	51.68	51.74
.3	51.35	51.40	51.45	51.51	51.57	51.62	51.67	51.72	51.78	51.83
.4	51.46	51.52	51.57	51.63	51.69	51.73	51.79	51.84	51.90	51.95
51.5	51.56	51.61	51.67	51.72	51.78	51.83	51.88	51.94	51.99	52.05
.6	51.65	51.71	51.76	51.82	51.88	51.93	51.98	52.04	52.09	52.15
.7	51.75	51.80	51.86	51.91	51.97	52.02	52.08	52.13	52.19	52.24
.8	51.84	51.90	51.95	52.01	52.07	52.12	52.17	52.23	52.28	52.34
.9	51.96	52.02	52.07	52.13	52.19	52.24	52.29	52.35	52.40	52.46
52.0	52.06	52.11	52.17	52.22	52.28	52.33	52.39	52.44	52.50	52.56
.1	52.15	52.21	52.26	52.32	52.38	52.43	52.49	52.54	52.60	52.65
.2	52.25	52.30	52.36	52.41	52.48	52.53	52.58	52.64	52.69	52.75
.3	52.35	52.40	52.46	52.51	52.57	52.62	52.68	52.73	52.79	52.85
.4	52.46	52.52	52.58	52.63	52.69	52.74	52.80	52.86	52.91	52.97
52.5	52.56	52.62	52.67	52.73	52.79	52.84	52.90	52.95	53.01	53.07
.6	52.66	52.71	52.77	52.82	52.89	52.94	52.99	53.05	53.11	53.16
.7	52.78	52.83	52.89	52.94	53.01	53.06	53.11	53.17	53.23	53.28
.8	52.85	52.90	52.96	53.02	53.08	53.13	53.19	53.24	53.30	53.36
.9	52.94	**53.00**	53.06	53.11	53.18	53.23	53.28	53.34	53.40	53.46
53.0	53.07	53.12	53.18	53.23	53.30	53.35	53.41	53.46	53.52	53.58
.1	53.16	53.22	53.27	53.33	53.39	53.45	53.50	53.56	53.62	53.68
.2	53.26	53.31	53.37	53.43	53.49	53.54	53.60	53.66	53.72	53.77
.3	53.35	53.41	53.47	53.53	53.59	53.64	53.70	53.76	53.81	53.87
.4	53.45	53.51	53.57	53.62	53.69	53.74	53.80	53.85	53.91	53.97
53.5	53.55	53.61	53.66	53.72	53.78	53.84	53.89	53.95	54.01	54.07
.6	53.65	53.70	53.76	53.82	53.88	53.93	53.99	54.05	54.11	54.17
.7	53.77	53.82	53.88	53.94	**54.00**	54.06	54.11	54.17	54.23	54.29
.8	53.86	53.92	53.98	54.04	54.10	54.15	54.21	54.27	54.33	54.39
.9	53.96	54.02	54.08	54.13	54.20	54.25	54.31	54.37	54.43	54.49
54.0	54.06	54.12	54.17	54.23	54.30	54.35	54.41	54.47	54.53	54.59
.1	54.16	54.21	54.27	54.33	54.40	54.45	54.51	54.57	54.62	54.68
.2	54.25	54.31	54.37	54.43	54.49	54.55	54.61	54.66	54.72	54.78
.3	54.35	54.41	54.47	54.53	54.59	54.64	54.70	54.76	54.82	54.88
.4	54.45	54.51	54.57	54.63	54.69	54.74	54.80	54.86	54.92	54.98
54.5	54.55	54.61	54.66	54.72	54.79	54.84	54.90	54.96	55.02	55.08
.6	54.67	54.73	54.79	54.85	54.91	54.97	55.03	55.09	55.15	55.21
.7	54.77	54.83	54.89	54.95	55.01	55.06	55.12	55.18	55.24	55.30
.8	54.87	54.93	54.98	55.04	55.11	55.16	55.22	55.28	55.34	55.40
.9	54.96	55.02	55.08	55.14	55.21	55.26	55.32	55.38	55.44	55.50

Gravity of dry oil in oil water mixture, deg. A.P.I. with percent water in mixture less than one suggested by R. W. Miller, Phillips Petroleum Company, Oklahoma City, Oklahoma.

PISTON AND ROD PACKINGS
—vital in this battle of Production!



COOK'S METALLIC ROD PACKINGS
for
ENGINES
(Steam—Diesel—Marine—Gas)
and
COMPRESSORS

(Air—Natural and Refinery Gases—Process Gas—and for Recycling and Repressuring Units)

★

There has been an approved type of COOK'S Packing developed for all service conditions backed by over 50 years' experience.

Of the many factors in today's battle of production the basic element is POWER—for **power comes before production!**

★

All builders and operators of power equipment know this—and appreciate the importance of keeping that equipment functioning (1) at highest efficiency and (2) with fewest possible interruptions for servicing.

★

This focuses attention on **piston and rod packings**—for they are prime factors in determining both operating efficiency and length of time power equipment will run without servicing.

★

For over 50 years COOK'S Graphitic Iron Piston Rings and COOK'S Metallic Rod Packings have been stand-bys of both builders and operators of industrial power equipment. Now, when it is necessary as never before to increase power, save fuel and reduce maintenance, the demand for COOK'S Rings and Metallic Packings, from Uncle Sam direct and from operators in all fields, is at an unprecedented peak. Needless to say we are going all out to meet all requirements—and we are meeting them.

★

So, if you need piston rings or rod packings—or have a problem pertaining to either—we're ready to serve you. Call or write our nearest office.

Sealing Pressures *Since 1888*

COOK'S GRAPHITIC IRON PISTON RINGS
for
ENGINES
(Steam—Diesel—Marine—Gas)
and
COMPRESSORS

(Air—Natural and Refinery Gases—Process Gas—and for Recycling and Repressuring Units)

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COOK'S Rings are available in all industrial engine sizes and types and in many special materials to meet unusual service conditions.

C. LEE COOK MANUFACTURING CO.
INCORPORATED

New York Cleveland Los Angeles Baltimore **LOUISVILLE, KY.** Chicago Tulsa New Orleans San Francisco

Static Press.
1300-1395 lb.

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Differential pressure in. of water	Static pressure, lb. per sq. in., ga.																			
	1300	1305	1310	1315	1320	1325	1330	1335	1340	1345	1350	1355	1360	1365	1370	1375	1380	1385	1390	1395
2	51.27	51.37	51.47	51.57	51.67	51.77	51.87	51.95	52.05	52.15	52.25	52.35	52.45	52.53	52.63	52.71	52.81	52.91	53.00	53.10
4	72.52	72.66	72.80	72.94	73.08	73.22	73.36	73.48	73.62	73.76	73.90	74.04	74.18	74.30	74.44	74.56	74.70	74.84	74.96	75.10
6	88.80	88.97	89.14	89.32	89.49	89.66	89.83	89.98	90.15	90.32	90.49	90.66	90.83	90.98	91.15	91.30	91.47	91.64	91.79	91.96
8	102.5	102.7	102.9	103.1	103.3	103.5	103.7	103.9	104.1	104.3	104.5	104.7	104.9	105.1	105.3	105.4	105.6	105.8	106.0	106.2
10	114.7	114.9	115.1	115.3	115.5	115.8	116.0	116.2	116.4	116.6	116.8	117.1	117.3	117.5	117.7	117.9	118.1	118.3	118.5	118.7
12	125.6	125.8	126.1	126.3	126.6	126.8	127.1	127.3	127.5	127.8	128.0	128.2	128.5	128.7	128.9	129.1	129.4	129.6	129.8	130.1
14	135.7	135.9	136.2	136.5	136.7	137.0	137.3	137.5	137.7	138.0	138.3	138.5	138.8	139.0	139.3	139.5	139.8	140.0	140.3	140.5
16	145.0	145.3	145.6	145.9	146.2	146.4	146.7	147.0	147.2	147.5	147.8	148.1	148.4	148.6	148.9	149.1	149.4	149.7	149.9	150.2
18	153.9	154.1	154.4	154.7	155.0	155.3	155.6	155.9	156.2	156.5	156.8	157.1	157.4	157.6	157.9	158.2	158.5	158.8	159.0	159.3
20	162.2	162.5	162.8	163.1	163.4	163.7	164.0	164.3	164.6	164.9	165.2	165.6	165.9	166.1	166.4	166.7	167.0	167.3	167.6	167.9
21	166.2	166.5	166.8	167.1	167.5	167.8	168.1	168.4	168.7	169.0	169.3	169.7	170.0	170.3	170.6	170.9	171.2	171.5	171.8	172.1
22	170.1	170.4	170.7	171.0	171.4	171.7	172.0	172.3	172.6	173.0	173.3	173.6	174.0	174.2	174.6	174.8	175.2	175.5	175.8	176.1
23	173.9	174.2	174.6	174.9	175.2	175.6	175.9	176.2	176.5	176.9	177.2	177.5	177.9	178.2	178.5	178.8	179.1	179.5	179.8	180.1
24	177.6	178.0	178.3	178.7	179.0	179.4	179.7	180.0	180.3	180.7	181.0	181.4	181.7	182.0	182.3	182.6	183.0	183.3	183.6	184.0
25	181.3	181.7	182.0	182.4	182.7	183.1	183.4	183.7	184.1	184.4	184.8	185.1	185.5	185.8	186.1	186.4	186.8	187.1	187.4	187.8
26	184.9	185.2	185.6	186.0	186.3	186.7	187.0	187.3	187.7	188.1	188.4	188.8	189.1	189.4	189.8	190.1	190.4	190.8	191.1	191.5
27	188.4	188.8	189.1	189.5	189.9	190.2	190.6	190.9	191.3	191.6	192.0	192.4	192.7	193.0	193.4	193.7	194.1	194.4	194.7	195.1
28	191.9	192.3	192.6	193.0	193.4	193.7	194.1	194.4	194.8	195.2	195.5	195.9	196.3	196.6	197.0	197.3	197.7	198.0	198.3	198.7
29	195.3	195.6	196.0	196.4	196.8	197.1	197.5	197.8	198.2	198.6	199.0	199.4	199.7	200.1	200.4	200.8	201.1	201.5	201.8	202.2
30	198.6	199.0	199.4	199.7	200.1	200.5	200.9	201.2	201.6	202.0	202.4	202.8	203.1	203.5	203.9	204.2	204.6	204.9	205.3	205.7
31	201.9	202.3	202.7	203.1	203.5	203.8	204.2	204.6	205.0	205.3	205.7	206.1	206.5	206.9	207.2	207.6	208.0	208.4	208.7	209.1
32	205.1	205.5	205.9	206.3	206.7	207.1	207.5	207.8	208.2	208.6	209.0	209.4	209.8	210.2	210.6	210.9	211.3	211.7	212.0	212.4
33	208.3	208.7	209.1	209.5	209.9	210.3	210.7	211.1	211.5	211.9	212.3	212.7	213.1	213.4	213.8	214.2	214.6	215.0	215.3	215.7
34	211.4	211.8	212.2	212.7	213.1	213.5	213.9	214.2	214.6	215.0	215.5	215.9	216.3	216.6	217.0	217.4	217.8	218.2	218.5	219.0
35	214.5	214.9	215.3	215.8	216.2	216.6	217.0	217.4	217.8	218.2	218.6	219.0	219.4	219.8	220.2	220.5	221.0	221.4	221.7	222.1
36	217.6	218.0	218.4	218.8	219.2	219.7	220.1	220.4	220.9	221.3	221.7	222.1	222.5	222.9	223.3	223.7	224.1	224.5	224.9	225.3
37	220.6	221.0	221.4	221.8	222.3	222.7	223.1	223.5	223.9	224.3	224.8	225.2	225.6	226.0	226.4	226.8	227.2	227.6	228.0	228.4
38	223.5	223.9	224.4	224.8	225.2	225.7	226.1	226.5	226.9	227.3	227.8	228.2	228.6	229.0	229.4	229.8	230.2	230.7	231.0	231.5
39	226.4	226.9	227.3	227.8	228.2	228.6	229.1	229.4	229.9	230.3	230.8	231.2	231.6	232.0	232.4	232.8	233.3	233.7	234.1	234.5
40	229.3	229.8	230.2	230.7	231.1	231.6	232.0	232.4	232.8	233.3	233.7	234.2	234.6	235.0	235.4	235.8	236.2	236.7	237.1	237.5
41	232.2	232.6	233.1	233.5	234.0	234.4	234.9	235.2	235.7	236.1	236.6	237.0	237.5	237.9	238.3	238.7	239.2	239.6	240.0	240.4
42	235.0	235.5	235.9	236.4	236.8	237.3	237.7	238.1	238.6	239.0	239.5	239.9	240.4	240.8	241.2	241.6	242.1	242.5	242.9	243.4
43	237.8	238.2	238.7	239.1	239.6	240.1	240.5	240.9	241.4	241.8	242.3	242.7	243.2	243.6	244.1	244.4	244.9	245.4	245.8	246.2
44	240.5	241.0	241.4	241.9	242.4	242.8	243.3	243.7	244.2	244.6	245.1	245.6	246.0	246.4	246.9	247.3	247.7	248.2	248.6	249.1
45	243.2	243.7	244.2	244.6	245.1	245.6	246.0	246.5	246.9	247.4	247.9	248.3	248.8	249.2	249.7	250.1	250.5	251.0	251.4	251.9
46	245.9	246.4	246.9	247.3	247.8	248.3	248.8	249.2	249.6	250.1	250.6	251.1	251.5	252.0	252.4	252.8	253.3	253.8	254.2	254.7
47	248.6	249.1	249.6	250.0	250.5	251.0	251.5	251.9	252.4	252.8	253.3	253.8	254.3	254.7	255.2	255.6	256.1	256.6	257.0	257.4
48	251.2	251.7	252.2	252.7	253.1	253.6	254.1	254.5	255.0	255.5	256.0	256.5	257.0	257.4	257.9	258.3	258.8	259.2	259.7	260.1
49	253.8	254.3	254.8	255.3	255.8	256.3	256.8	257.2	257.7	258.2	258.7	259.1	259.6	260.1	260.5	261.0	261.5	261.9	262.4	262.9
50	256.4	256.9	257.4	257.9	258.4	258.9	259.4	259.8	260.3	260.8	261.3	261.8	262.3	262.7	263.2	263.6	264.1	264.6	265.0	265.5
51	258.9	259.4	259.9	260.4	260.9	261.4	261.9	262.4	262.9	263.4	263.9	264.4	264.9	265.3	265.8	266.2	266.7	267.2	267.6	268.1
52	261.5	262.0	262.5	263.0	263.5	264.0	264.5	264.9	265.4	265.9	266.4	267.0	267.5	267.9	268.4	268.8	269.3	269.8	270.3	270.8
53	264.0	264.5	265.0	265.5	266.0	266.5	267.0	267.5	268.0	268.5	269.0	269.5	270.0	270.5	271.0	271.4	271.9	272.4	272.9	273.4
54	266.4	267.0	267.5	268.0	268.5	269.0	269.5	270.0	270.5	271.0	271.5	272.0	272.5	273.0	273.5	274.0	274.4	275.0	275.4	275.9
55	268.9	269.4	269.9	270.5	271.0	271.5	272.0	272.5	273.0	273.5	274.0	274.5	275.1	275.5	276.0	276.5	277.0	277.5	278.0	278.5
56	271.3	271.9	272.4	273.0	273.4	274.0	274.5	275.0	275.5	276.0	276.5	277.0	277.5	278.0	278.5	279.0	279.5	280.0	280.5	281.0
57	273.8	274.3	274.8	275.3	275.9	276.4	276.9	277.4	277.9	278.4	279.0	279.5	280.0	280.5	281.0	281.5	282.0	282.5	283.0	283.5
58	276.2	276.7	277.2	277.8	278.3	278.8	279.4	279.8	280.3	280.9	281.4	281.9	282.5	282.9	283.5	283.9	284.5	285.0	285.4	286.0
59	278.5	279.1	279.6	280.1	280.7	281.2	281.7	282.2	282.7	283.3	283.8	284.4	284.9	285.3	285.9	286.3	286.9	287.4	287.9	288.4
60	280.9	281.4	282.0	282.5	283.0	283.6	284.1	284.6	285.1	285.7	286.2	286.8	287.3	287.8	288.3	288.8	289.3	289.9	290.3	291.0
61	283.2	283.7	284.3	284.8	285.4	285.9	286.5	286.9	287.5	288.0	288.6	289.1	289.7	290.1	290.7	291.2	291.7	292.3	292.7	293.3
62	285.5	286.1	286.6	287.2	287.7	288.3	288.8	289.3	289.8	290.4	290.9	291.5	292.0	292.5	293.1	293.5	294.1	294.6	295.1	295.7
63	287.8	288.4	288.9	289.5	290.0	290.6	291.1	291.6	292.2	292.7	293.3	293.8	294.4	294.9	295.4	295.9	296.4	297.0	297.5	298.0
64	290.1	290.6	291.2	291.8	292.3	292.9	293.4	293.9	294.5	295.0	295.6	296.2	296.7	297.2	297.8	298.2	298.8	299.4	299.8	300.4
65	292.3	292.9	293.5	294.0	294.6	295.1	295.7	296.2	296.8	297.3	297.9	298.5	299.0	299.5	300.1	300.6	301.1	301.7	302.2	302.7
66	294.6	295.1	295.7	296.3	296.9	297.4	298.0	298.5	299.0	299.6	300.2	300.8	301.3	301.8	302.4	302.9	303.4	304.0	304.5	305.1
67	296.8	297.4	297.9	298.5	299.1	299.7	300.2	300.7	301.3	301.9	302.4	303.0	303.6	304.1	304.6	305.1	305.7	306.3	306.8	307.3
68	299.0	299.6	300.2	300.7	301.3	301.9	302.5	303.0	303.5	304.1	304.7	305.3	305.8	306.3	306.9	307.4	308.0	308.6	309.1	309.6
69	301.2	301.8	302.4	303.0	303.5	304.1	304.7	305.2	305.8	306.4	306.9	307.5	308.1	308.6	309.2	309.7	310.3	310.8	311.3	311.9
70	303.4	304.0	304.6	305.1	305.7	306.3	306.9	307.4	308.0	308.6	309.2	309.7	301.3	310.8	311.4	311.9	312.5	313.1	313.6	314.2
71	305.5	306.1	306.7	307.3	307.9	308.5	309.1	309.6	310.2	310.8	311.3	311.9	312.5	313.0	313.6	314.1	314.7	315.3	315.8	316.4
72	307.7	308.3	308.9	309.4	310.0	310.6	311.2	311.7	312.3	312.9	313.5	314.1	314.7	315.2	315.8	316.3	316.9	317.5	318.0	318.6
73	309.8	310.4	311.0	311.6	312.2	312.8	313.4	313.9	314.5	315.1	315.7	316.3	316.9	317.4	318.0	318.5	319.1	319.7	320.2	320.8
74	311.9	312.5	313.1	313.7	314.3	314.9	315.5	316.0	316.6	317.2	317.8	318.4	319.0	319.6	320.2	320.7	321.3	321.9	322.4	323.0
75	314.0	314.6	315.2	315.8	316.4	317.0	317.6	318.2	318.8	319.4	320.0	320.6	321.2	321.7	322.3	322.8	323.5	324.1	324.6	325.2
76	316.1	316.7	317.3	317.9	318.6	319.2	319.8	320.3	320.9	321.5	322.1	322.7	323.4	323.9	324.5	325.0	325.6	326.2	326.8	327.4
77	318.2	318.8	319.4	320.0	320.6	321.3	321.9	322.4	323.0	323.6	324.2	324.9	325.5	326.0	326.6	327.1	327.7	328.4	328.9	329.5
78	320.2	320.9	321.5	322.1	322.7	323.3	324.0	324.5	325.1	325.7	326.3	327.0	327.6	328.1	328.7	329.3	329.9	330.5	331.0	331.6
79	322.3	322.9	323.5	324.1	324.8	325.4	326.0	326.5	327.2	327.8	328.4	329.0	329.7	330.2	330.8	331.3	332.0	332.6	333.1	333.7
80	324.3	324.9	325.6	326.2	326.8	327.4	328.1	328.6	329.2	329.9	330.5	331.1	331.7	332.3	332.9	333.4	334.1	334.7	335.2	335.8
82	328.3	329.0	329.6	330.2	330.9	331.5	332.1	332.7	333.3	333.9	334.6	335.2	335.8	336.4	337.0	337.6	338.2	338.8	339.4	340.0
84	332.3	333.0	333.6	334.2	334.9	335.5	336.2	336.7	337.4	338.0	338.6	339.3	339.9	340.5	341.1	341.7	342.3	343.0	343.5	344.1
86	336.3	336.9	337.6	338.2	338.9	339.5	340.2	340.7	341.4	342.0	342.7	343.3	344.0	344.5	345.2	345.7	346.4	347.0	347.6	348.2
88	340.2	340.8	341.5	342.1	342.8	343.4	344.1	344.7	345.3	346.0	346.6	347.3	347.9	348.5	349.2	349.7	350.4	351.0	351.6	352.3
90	344.0	344.7	345.3	346.0	346.7	347.3	348.0	348.6	349.2	349.9	350.5	351.2	351.9	352.4	353.1	353.7	354.3	355.0	355.6	356.2
92	347.8	348.5	349.1	349.8	350.5	351.2	351.8	352.4	353.1	353.8	354.4	355.1	355.8	356.3	357.0	357.6	358.3	358.9	359.5	360.2
94	351.5	352.2	352.9	353.6	354.3	354.9	355.6	356.2	356.9	357.6	358.2	358.9	359.6	360.2	360.8	361.4	362.1	362.8	363.4	364.0
96	355.3	356.0	356.6	357.3	358.0	358.7	359.4	360.0	360.7	361.4	362.0	362.7	363.4	364.0	364.7	365.3	366.0	366.6	367.2	367.9
98	358.9	359.6	360.3	361.0	361.7	362.4	363.1	363.7	364.4	365.1	365.8	366.5	367.2	367.7	368.4	369.0	369.7	370.4	371.0	371.7
100	362.6	363.3	364.0	364.7	365.4	366.1	366.8	367.4	368.1	368.8	369.5	370.2	370.9	371.5	372.2	372.8	373.5	374.2	374.8	375.5

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in. abs. and in. inches of water respectively.

Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.

Table has been condensed to serve field men in approximating meter reading, intermediate readings for accurate measurements may of water, respectively.

"CHIEF, IT LOOKS AS THOUGH WE WON'T BE ABLE TO GET THAT NEW EQUIPMENT"
"THEN LET'S PLAN FOR MORE STAYNEW FILTERS TO KEEP OUR PRESENT EQUIPMENT AT PEAK EFFICIENCY"

Check Your Needs Now FOR STAYNEW FILTERS

Not only are many suppliers unable to deliver new equipment, but nowadays competent repair service is often unavailable. Present equipment *must* be made to last! One of the best ways to assure its continuous, repair-free operation is to protect it with Staynew Filters. Staynew builds filters for your compressor and engine protection, pipe lines, building ventilation, air, gas, and liquids. Sizes and types are made for nearly every requirement. If necessary, Staynew engineers will adapt present models or design new ones for your special needs. "Keep 'Em New" with *Staynew Filters*.

☆☆☆

WRITE FOR CATALOG today, and find out how your equipment can be made to last longer and operate more efficiently when Staynew-Filter-protected.

COMPRESSOR AND ENGINE INTAKE
Model D

Air drawn into intakes of compressors, pumps, Diesels and other internal combustion engines must be clean. Dust scores cylinder walls, clogs valves, causes excessive carbon formation, wears all reciprocating and rotating parts. Model D Filters, featuring famous Radial Fin Construction prevent dust intake at 99.8% efficiency as rated by University of California tests, yet show level resistance curves at a peak of only 1" W. G. after 12 months use. Silencer models available.

PIPE LINE
Model CPHS

Dust, dirt, moisture, pipe scale in air and gas lines cause damage to air-powered tools and to many processes. Foreign matter in liquid lines (for oil, water, acid, etc.), may cause excessive wear, prevent proper reactions. Models CP, CPH, CPHS, CPHLS, and AAPHS guard innumerable machines and operations. Featured Radial Fin Construction permits high filtering efficiency, low restriction to flow.

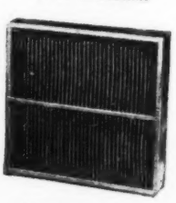
BUILDING AND ENGINE ROOM VENTILATION
Automatic

Employee health, as well as the proper operation and protection of much vital equipment depend on clean air. Motors, transformers, turbo-generators, etc., etc., must be supplied with dust-free air. Staynew Automatic Filters deliver large volumes of clean air at low cost; Panel Filters offer highest possible efficiency with low restriction to air flow; Wire-Klad Filters feature low initial cost, long life and fire resistance.

Panel

(Intake Side)

Wire-Klad



(Outlet Side)

STAYNEW FILTER CORP.

"Filter Headquarters"

PROTECTOMOTOR 99 10/100 Per Cent AIR FILTERS

2 Centre Park, Rochester, N. Y.

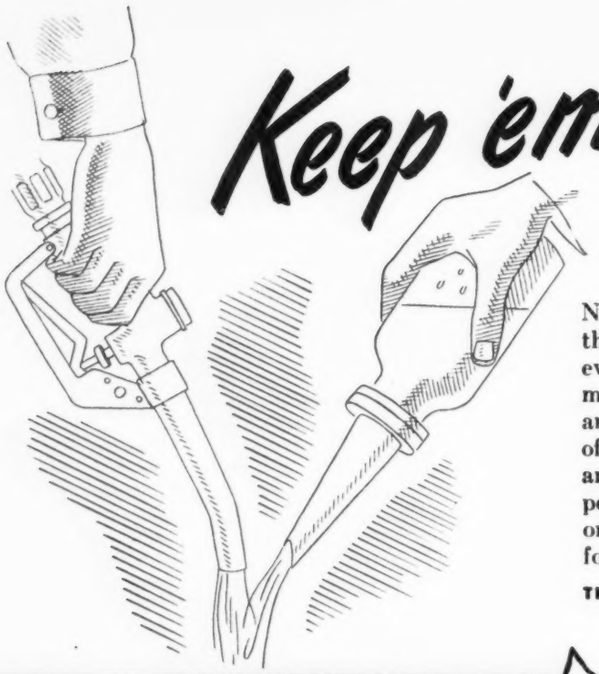
WEIGHT OF DRY MATERIAL ADDED TO DRILLING MUD LB. PER GAL. SP. GR. OF ADDITIVE 2.70

Original fluid, mud or water		Desired mud weight, lb. per gal.																					
weight lb. per gal.		9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5
	Specific Gravity	1.08	1.14	1.20	1.26	1.32	1.38	1.44	1.50	1.56	1.62	1.68	1.74	1.80	1.86	1.92	1.98	2.04	2.10	2.16	2.22	2.28	2.34
*8.345	1.00	1.13	2.03	3.00	4.05	5.20	6.51	7.87	9.38	11.1	12.9	15.1	17.4	20.0	23.0	26.5	30.7	35.5	41.3	48.3	57.2	68.7	83.9
9.0	1.08		0.85	1.78	2.84	3.93	5.12	6.42	7.86	9.51	11.3	13.3	15.4	18.0	20.9	24.3	28.2	32.7	38.2	45.1	53.5	64.3	78.7
9.5	1.14			0.89	1.85	2.96	4.10	5.36	6.74	8.26	10.0	11.9	14.1	16.5	19.3	22.6	26.3	30.7	36.0	42.5	50.7	61.1	75.1
10.0	1.20				0.93	1.93	3.09	4.30	5.63	7.10	8.76	10.6	12.7	15.0	17.7	20.8	24.4	28.7	33.8	40.0	47.8	58.0	71.4
10.5	1.26					0.97	2.02	3.24	4.52	5.93	7.49	9.26	11.3	13.5	16.1	19.0	22.4	26.7	31.5	37.5	45.0	54.6	67.6
11.0	1.32						1.01	2.12	3.40	4.75	6.26	7.93	9.84	12.0	14.5	17.3	20.6	24.5	29.3	35.0	42.2	51.5	63.7
11.5	1.38							1.06	2.23	3.59	5.02	6.62	8.42	10.5	12.9	15.6	18.8	22.5	26.9	32.6	39.4	48.3	60.0
12.0	1.44								1.11	2.34	3.79	5.31	7.04	9.01	11.3	13.9	16.9	20.4	24.8	29.9	36.7	45.1	56.3
12.5	1.50									1.17	2.47	4.00	5.65	7.51	9.59	12.1	15.1	18.4	22.5	27.5	33.7	41.9	52.6
13.0	1.56										1.23	2.62	4.26	6.02	8.04	10.3	13.1	16.4	20.3	25.0	30.9	38.5	48.9
13.5	1.62											1.31	2.78	4.54	6.46	8.67	11.3	14.3	18.1	22.5	28.2	35.4	45.0
14.0	1.68												1.39	2.97	4.86	6.95	9.42	12.3	15.7	20.1	25.4	32.2	41.2
14.5	1.74													1.48	3.18	5.24	7.53	10.3	13.5	17.4	22.6	29.0	37.5
15.0	1.80														1.58	3.42	5.68	8.21	11.3	15.0	19.6	25.9	33.9
15.5	1.86															1.71	3.70	6.19	9.01	12.5	16.8	22.4	30.1
16.0	1.92																1.85	4.04	6.81	10.0	14.1	19.3	26.2
16.5	1.98																	2.02	4.45	7.56	11.3	16.1	22.4
17.0	2.04																		2.23	4.95	8.51	12.9	18.8
17.5	2.10																			2.47	5.56	9.76	15.1
18.0	2.16																				2.78	6.36	11.3
18.5	2.22																					3.18	7.41
19.0	2.28																						3 75

Note: The body of this table supplies the weight in lb. of the dry solid to be added per gal. to a drilling fluid of known weight to obtain a mud of higher weight. The above table was calculated with an additive of specific gravity 2.70 (average sp. gr. of Dolomite, limestone, slate, calcite, and talc).

To use table find weight of original mud in left hand col. and desired mud weight in top line. Multiply figure from body of table by the vol. of mud in gal. in well or mud pit to obtain the total amount in lb. of dry material to be added to obtain the desired mud weight.

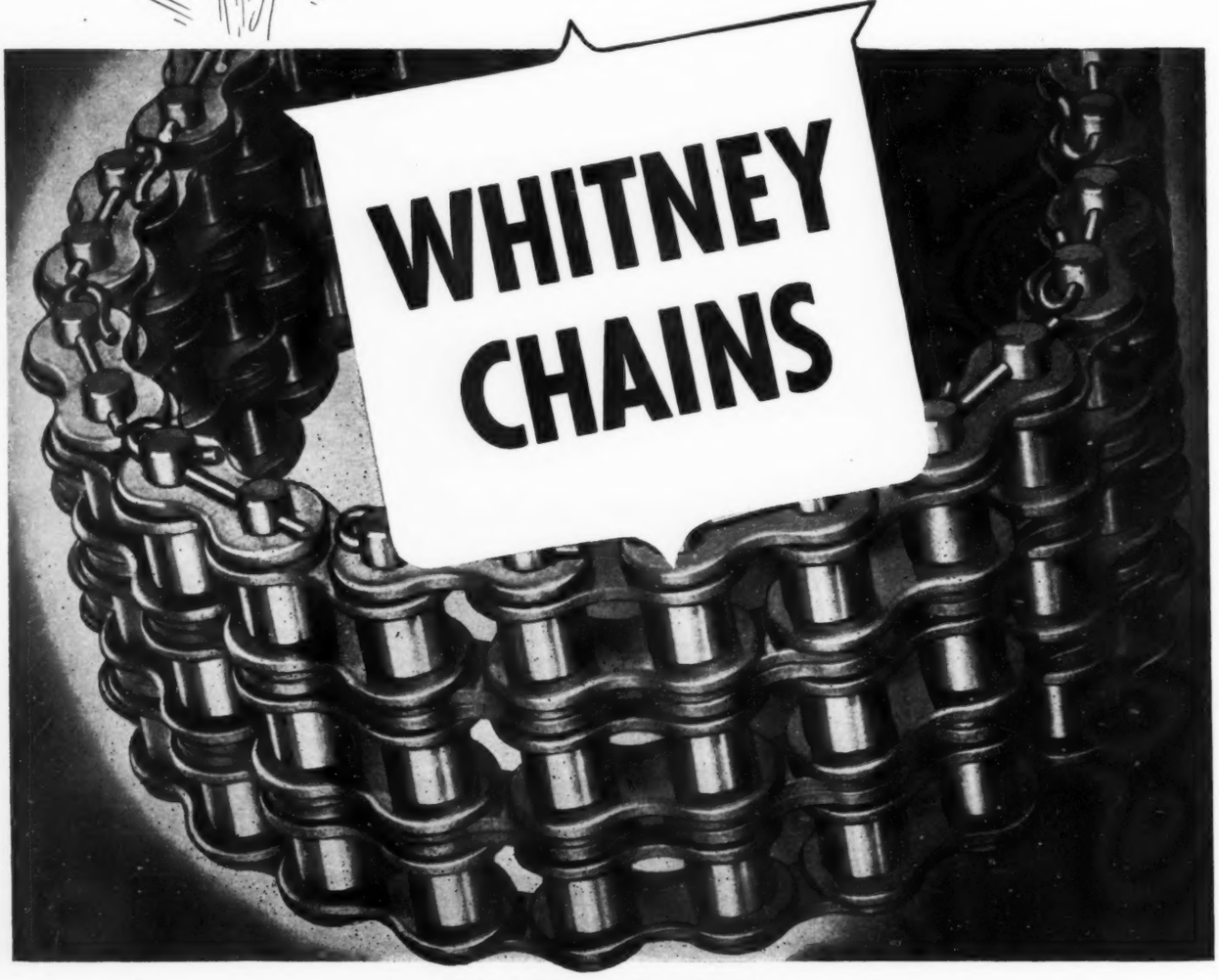
*Water.



Keep 'em Flowing for Victory

Now, full production of motor fuels and lubricants is the lifestream of Victory. So now it is more vital than ever to keep full power flowing to all your field equipment on Whitney Roller Chains . . . the chains that are armored with extra-tough alloy steels to stand the gaff of 24-hour operation without shutdowns or slow-downs, and to stay on the job long past usual chain-life expectancy. Make sure to make all *your* drives Whitney, on all present and new equipment, and you're all set for top operating capacity at lowest cost per drive-unit.

THE WHITNEY CHAIN & MFG. CO., HARTFORD, CONN.



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The Whitney Chain & Mfg. Co., 2826 Elm St., Dallas, Texas

West Coast

Engineering Products Co., 747 Warehouse St., Los Angeles, California

SAPONIFICATION NUMBERS—OILS CONTAINING MORE THAN 30% FATTY OILS—METHOD A

D = 4.90 — 5.10

Value of D[1]	Weight of oil sample, w, grams.																				
	4.90	4.91	4.92	4.93	4.94	4.95	4.96	4.97	4.98	4.99	5.00	5.01	5.02	5.03	5.04	5.05	5.06	5.07	5.08	5.09	5.10
35.0	200.	200.	199.	199.	199.	198.	198.	198.	197.	197.	196.	196.	196.	195.	195.	194.	194.	194.	193.	193.	192.
35.1	201.	200.	200.	200.	199.	199.	198.	198.	198.	197.	197.	197.	196.	196.	195.	195.	195.	194.	194.	193.	193.
35.2	201.	201.	201.	200.	200.	199.	199.	199.	198.	198.	197.	197.	197.	196.	196.	195.	195.	195.	194.	194.	194.
35.3	202.	202.	201.	201.	200.	200.	200.	199.	199.	198.	198.	198.	197.	197.	196.	196.	196.	195.	195.	194.	194.
35.4	203.	202.	202.	201.	201.	201.	200.	200.	199.	199.	199.	198.	198.	197.	197.	197.	196.	196.	195.	194.	195.
35.5	203.	203.	202.	202.	202.	201.	201.	200.	200.	200.	199.	199.	198.	198.	198.	197.	197.	196.	196.	196.	195.
35.6	204.	203.	203.	203.	202.	202.	201.	201.	201.	200.	200.	199.	199.	199.	198.	198.	197.	197.	197.	196.	196.
35.7	204.	204.	203.	203.	203.	202.	202.	201.	201.	201.	200.	200.	199.	199.	199.	198.	198.	197.	197.	197.	196.
35.8	205.	204.	204.	204.	203.	203.	202.	202.	202.	201.	201.	200.	200.	200.	199.	199.	198.	198.	198.	197.	197.
35.9	205.	205.	205.	204.	204.	203.	203.	203.	202.	202.	201.	201.	201.	200.	200.	199.	199.	199.	198.	198.	197.
36.0	206.	206.	205.	205.	204.	204.	204.	203.	203.	202.	202.	202.	201.	201.	200.	200.	200.	199.	199.	198.	198.
36.1	207.	206.	206.	205.	205.	205.	204.	204.	203.	203.	203.	202.	202.	201.	201.	200.	200.	200.	199.	199.	198.
36.2	207.	207.	206.	206.	206.	205.	205.	204.	204.	203.	203.	203.	202.	202.	201.	201.	201.	200.	200.	199.	199.
36.3	208.	207.	207.	206.	206.	206.	205.	205.	204.	204.	204.	203.	203.	202.	202.	202.	201.	201.	200.	200.	200.
36.4	208.	208.	207.	207.	207.	206.	206.	205.	205.	205.	204.	204.	203.	203.	203.	202.	202.	201.	201.	201.	200.
36.5	209.	208.	208.	208.	207.	207.	206.	206.	206.	205.	205.	204.	204.	204.	203.	203.	202.	202.	201.	201.	201.
36.6	209.	209.	209.	208.	208.	207.	207.	207.	206.	206.	205.	205.	205.	204.	204.	203.	203.	202.	202.	202.	201.
36.7	210.	210.	209.	209.	208.	208.	208.	207.	207.	206.	206.	205.	205.	205.	204.	204.	203.	203.	203.	202.	202.
36.8	211.	210.	210.	209.	209.	209.	208.	208.	207.	207.	206.	206.	206.	205.	205.	204.	204.	204.	203.	203.	202.
36.9	211.	211.	210.	210.	209.	209.	209.	208.	208.	207.	207.	207.	206.	206.	205.	205.	205.	204.	204.	203.	203.
37.0	212.	211.	211.	210.	210.	210.	209.	209.	208.	208.	208.	207.	207.	206.	206.	205.	205.	205.	204.	204.	203.
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37.2	213.	212.	212.	212.	211.	211.	210.	210.	210.	209.	209.	208.	208.	207.	207.	207.	206.	206.	205.	205.	205.
37.3	213.	213.	213.	212.	212.	211.	211.	211.	210.	210.	209.	209.	208.	208.	208.	207.	207.	206.	206.	205.	205.
37.4	214.	214.	213.	213.	212.	212.	211.	211.	211.	210.	210.	209.	209.	209.	208.	208.	207.	207.	206.	206.	206.
37.5	215.	214.	214.	213.	213.	212.	212.	212.	211.	211.	210.	210.	210.	209.	209.	208.	208.	207.	207.	207.	206.
37.6	215.	215.	214.	214.	213.	213.	213.	212.	212.	211.	211.	211.	210.	210.	209.	209.	208.	208.	208.	207.	207.
37.7	216.	215.	215.	214.	214.	214.	213.	213.	212.	212.	211.	211.	211.	210.	210.	209.	209.	209.	208.	208.	207.
37.8	216.	216.	215.	215.	215.	214.	214.	213.	213.	212.	212.	212.	211.	211.	210.	210.	210.	209.	209.	208.	208.
37.9	217.	216.	216.	216.	215.	215.	214.	214.	213.	213.	213.	212.	212.	211.	211.	210.	210.	210.	209.	209.	208.
38.0	217.	217.	217.	216.	216.	215.	215.	214.	214.	214.	213.	213.	212.	212.	211.	211.	211.	210.	210.	209.	209.
38.1	218.	218.	217.	217.	216.	216.	215.	215.	215.	214.	214.	213.	213.	212.	212.	212.	211.	211.	210.	210.	209.
38.2	219.	218.	218.	217.	217.	216.	216.	216.	215.	215.	214.	214.	213.	213.	213.	212.	212.	211.	211.	210.	210.
38.3	219.	219.	218.	218.	217.	217.	217.	216.	216.	215.	215.	214.	214.	214.	213.	213.	212.	212.	211.	211.	211.
38.4	220.	219.	219.	218.	218.	218.	217.	217.	216.	216.	215.	215.	215.	214.	214.	213.	213.	212.	212.	212.	211.
38.5	220.	220.	219.	219.	219.	218.	218.	217.	217.	216.	216.	216.	215.	215.	214.	214.	213.	213.	213.	212.	212.
38.6	221.	220.	220.	220.	219.	219.	218.	218.	217.	217.	217.	216.	216.	215.	215.	214.	214.	214.	213.	213.	212.
38.7	221.	221.	221.	220.	220.	219.	219.	218.	218.	218.	217.	217.	216.	216.	215.	215.	215.	214.	214.	213.	213.
38.8	222.	222.	221.	221.	220.	220.	219.	219.	219.	218.	218.	217.	217.	216.	216.	215.	215.	215.	214.	214.	213.
38.9	223.	222.	222.	221.	221.	220.	220.	220.	219.	219.	218.	218.	217.	217.	216.	216.	216.	215.	215.	214.	214.
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39.2	224.	224.	223.	223.	223.	222.	222.	221.	221.	220.	220.	219.	219.	219.	218.	218.	217.	217.	216.	216.	216.
39.3	225.	224.	224.	224.	223.	223.	222.	222.	221.	221.	220.	220.	220.	219.	219.	218.	218.	217.	217.	217.	216.
39.4	225.	225.	225.	224.	224.	223.	223.	222.	222.	221.	221.	221.	220.	220.	219.	219.	218.	218.	217.	217.	217.
39.5	226.	226.	225.	225.	224.	224.	223.	223.	222.	222.	222.	221.	221.	220.	220.	219.	219.	218.	218.	218.	217.
39.6	227.	226.	226.	225.	225.	224.	224.	223.	223.	223.	222.	222.	221.	221.	220.	220.	219.	219.	219.	218.	218.
39.7	227.	227.	226.	226.	225.	225.	224.	224.	224.	223.	223.	222.	222.	221.	221.	220.	220.	220.	219.	219.	218.
39.8	228.	227.	227.	226.	226.	226.	225.	225.	224.	224.	223.	223.	222.	222.	221.	221.	221.	220.	220.	219.	219.
39.9	228.	228.	227.	227.	227.	226.	226.	225.	225.	224.	224.	223.	223.	222.	222.	222.	221.	221.	220.	220.	219.

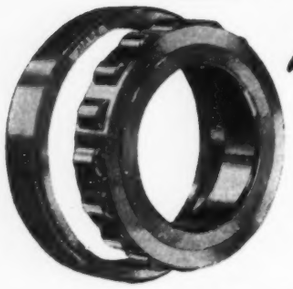
[1] D = difference between the number of milliliters of 0.5N HCl required for the determination and the average of the two blanks run on the alcoholic potassium hydroxide solution.

The above saponification numbers are calculated by the formula: $$\text{Saponification number} = \frac{D \times 28.05}{w}$$

This formula is from "Test for Saponification Number," A.S.T.M. (D94-39T).

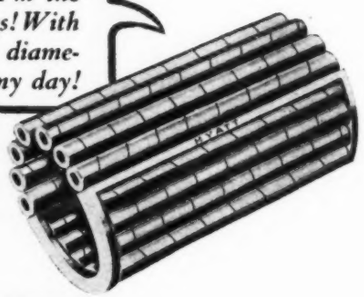
For additional notes, see tables indexed P 747.501.10.

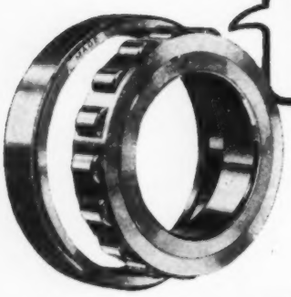
Said 1942 to 1892



1942: *Hi, Old Timer!*

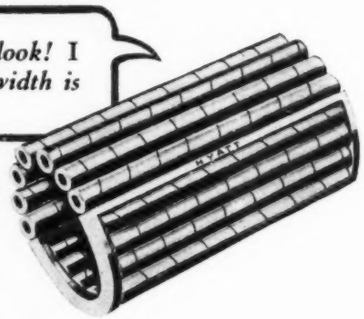
1892: *A little more respect, please. I'm the daddy of our great line of Hyatt Bearings! With a tolerance of .010 in my wound roller diameters I was the Number One bearing of my day!*

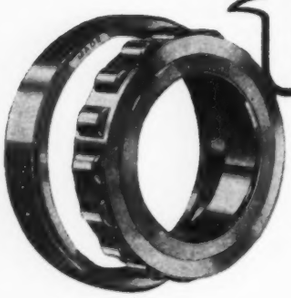




1942: Okay Dad, but with my modern design and close tolerance of one ten-thousandth of an inch, I'm the "fair-haired boy" today.

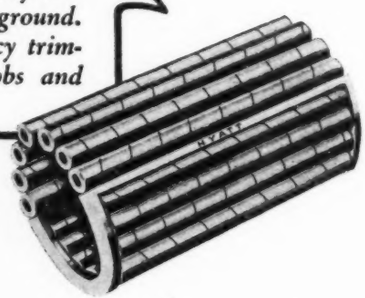
1892: *Hmph! But how skinny you look! I had a width of 6-7 inches while your width is only 1-1½ inches, young fellow.*

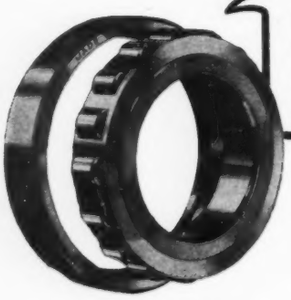




1942: I'm streamlined, old man, but what capacity I possess. And I'm a pretty slick article with my inner and outer race, and my ultra finish.

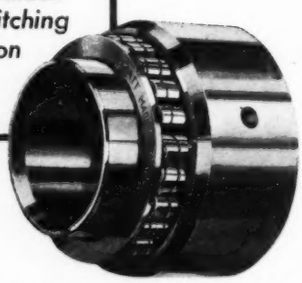
1892: *I know . . . I've watched you develop over fifty years. Sure I was made of only low carbon steel and my finish wasn't even ground. In my day, we didn't have all the fancy trimmings — but we handled the tough jobs and handled them well!*





1942: I appreciate all that, old fellow, but think how out-of-place you would be today with that crude half-spacer roller retainment as compared to my swanky bronze cage and microscopically finished solid rollers and races.

1892-1942: You're right, lad. But look me over now. Other than in roller design I've changed considerably during these years. And I'm still in there pitching with you where applications call for my lubrication features and shock load advantages. So—give credit where credit is due!



THE 50TH YEAR OF

HYATT ROLLER BEARINGS

HYATT BEARINGS DIVISION, GENERAL MOTORS CORPORATION, HARRISON, NEW JERSEY

Running Tour

WITH MEN IN THE INDUSTRY

R. H. CRAMER has been appointed factory manager of the Hyatt Bearings Division, General Motors Corporation in Harrison, New Jersey, according to an announcement by H. O. K. MEISTER, general manager. Cramer succeeds C. P. MILLARD, who has resigned, and has been with Hyatt since 1922.

W. W. HEATHMAN is now manager of a new office opened by the Union Oil Company of California at 815 Union National Bank Building, Wichita, Kansas.

RALPH R. NEWQUIST has been named assistant to WALTER GEIST, vice-president of the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin. Newquist formerly was manager of the Allis-Chalmers company's district office at Houston, Texas. He joined the company in 1934. Newquist is succeeded as manager of the Houston office by C. W. SCHWEERS

OTTO KOCH was re-elected president and treasurer of the Kendall Refining Company at a meeting of directors, following the annual meeting of stockholders at Bradford, Pennsylvania.

HEATH RENFRO is now in the production department of Tide Water Associated Oil Company in Texas. Renfro was formerly with the Texas Railroad Commission stationed at Houston, Texas.

W. W. SCHEUMANN and L. D. MANN, Cities Service Oil Company, have been given promotions, according to H. W. CAMP, manager of refining. Scheumann, chief chemist, is now general superintendent of oil refining, succeeding LOUIS D. MANN, who resigned to become general manager of a new subsidiary the company has formed to process chemicals from gas in Arkansas. Scheumann will supervise the Ponca City and Okmulgee, Oklahoma, and East Chicago, Indiana, refineries.

J. A. LYON, chief engineer in District 3, Texas Railroad Commission, Houston, has resigned to open consulting offices in that city. Lyon has been chief engineer since April, 1940.

W. R. NEWMAN has left his position as general superintendent of the Bay Petroleum Company, Denver, Colorado, and is now vice-president in charge of manufacturing of the Frontier Refining Company of Denver and Cheyenne, Wyoming.

FRANK FAVOY, JR., has succeeded D. D. GOOCH as petroleum engineer in charge of the Lake Charles, Louisiana, office of the Minerals Division, Louisiana Conservation Department. Gooch has been transferred to Lafayette, Louisiana.

GUY A. TOMPSON, vice-president and general manager of Bethlehem Supply Company, has returned to Tulsa, Oklahoma, after having served in the procurement division of the War Production Board for the last six months.

W. S. ZEHRUNG, president of the Pennzoil Company, was elected chairman of the Associated Petroleum Industries of Pennsylvania at the annual meeting of the association. He succeeds SAMUEL MESSER.

O. W. MALONEY has been elected president of Maloney Tank Manufacturing Company, Tulsa, Oklahoma. Other officers are J. S. WARREN, chairman of the board and treasurer; J. C. HIGHFILL, vice-president and manager; C. M. WARREN, secretary; T. J. COSTELLO, sales manager, and J. S. WARREN, JR., sales engineer, and in charge of government defense orders.

EARL LAMERE, Waukesha Motor Company service man known to oil men in both the United States and South America, is now in Colombia, South America, working with the Colombian National Railways on the new trains recently placed in service that are powered with Waukesha-Hesselmans.

BEN H. RAVANELL, with the Oil Well Supply Company since 1933, has resigned as development engineer and is now a mechanical engineer with the Guiberson Diesel Engine Company, Dallas, Texas. The company is now in production on the Guiberson Diesel tank engine.

PETER VOSS, who recently completed a 24-year period of service with the Timken Roller Bearing Company, Canton, Ohio, has retired. Voss served as a clerk in the purchasing department, as purchasing agent, and since 1934 has served as director of purchases.

L. L. GAMBLE, Daugherty Refinery, Petrolia, is president of the Pennsylvania Refiners Traffic Association, whose membership represents refiners in western Pennsylvania, southeast New York, West Virginia, and southeastern Ohio.

L. W. STORM, Schlumberger Well Surveying Corporation, delivered an address before the West Texas Geological Society at Midland, Texas, February 23 on "A Resumé of Current Opinion on Larger Features of Gulf Coast Sedimentation."

JAMES F. TOWERS is the new president of Ford, Bacon and Davis, Inc., New York, New York, design, construction, and operating engineers. He succeeds WILLIAM VON PHUL, who is now chairman of the executive committee.

K. J. BALENKO, petroleum engineer, has been transferred from Odessa, Texas, by the Phillips Petroleum Company to Bartlesville, Oklahoma, in the company's natural gasoline department.

SOL SMITH, district engineer at Wichita Falls for the Texas Railroad Commission, has resigned to accept a position as assistant chemical engineer with the War Department, Chemical Warfare Service, at the Huntsville Arsenal, Huntsville, Alabama.

O. M. MYERS, mechanical and petroleum engineer, Shawnee, Oklahoma, is to leave for Abadan, Iran, to assist in building new plants at refineries there. Myers recently returned from service on a refinery in Canada.

M. S. LOY, Sloan and Zook Oil Company, has been transferred from West Texas to Chanute, Kansas, to superintend water-flooding operations.

FRED P. SHAYES, geologist of the Union Oil Company, Beeville, Texas, presented a paper on "Geology of the Agua Dulce and Stratton Fields in Western Nueces County," to the South Texas Geological Society at Corpus Christi, Texas, February 27.

EDWIN L. DENNIS, chief combustion engineer of the Coppus Engineering Corporation, Worcester, Massachusetts, has requested that he be relieved of his duties as instructor at Louisiana State University, Baton Rouge, Louisiana, in order to devote his full energies to the increasingly vital problem of efficient combustion in industrial plants.

ALAN G. WIKOFF, editor-in-chief of the general publicity department of Union Carbide and Carbon Corporation, New York, New York, died in White Plains, New York, February 11 at the age of 46. His home was in Pleasantville, New York.

ALBERT A. HANIFORD has been appointed to the sales department of Manning, Maxwell, and Moore, Inc., to extend the sales training program for company representatives. Haniford has previously served as assistant to the director of dealer relations for Johns-Manville.

V. E. EKHOLM, consulting geologist of Dallas, Texas, has been made general manager and chief geologist for the Bolivian government in its operation of oil properties recently purchased from the Standard Oil Company of Bolivia, South America, a subsidiary of the Standard Oil Company of New Jersey, Ekholm was formerly a consulting geologist for the Primrose Oil Company.

ED. REID, superintendent for the Arrow Drilling Company, has been transferred from Illinois to Shawnee, Oklahoma.

L. J. FRODIN has succeeded JOHN CATTERALL as office manager of the Whiting refinery of Standard Oil Company of Indiana. Catterall has been transferred to other duties, according to President EDWARD G. SEUBERT, and CLAUDE YATES has been appointed assistant office manager at the refinery.

J. D. CREVELING, president of Panhandle Eastern Pipe Line Company, has announced that the company has paid $10,766,715 to the Columbia Gas and Electric Corporation in consideration of its acquisition of Michigan Gas Transmission Corporation and the Indiana Gas Distribution Corporation, and has paid $439,326 for certain other properties.

BOYD KOEPKE, Clark Bros. Co. engineer, is now assistant to E. E. ROBBINS in the Office of Petroleum Coordinator in Tulsa, Oklahoma.

JAMES ANDERSON, vice-president and treasurer of the Humble Oil and Refining Company, Houston, Texas, has been elected president of the Houston Community Chest and Council.

J. W. HOUSE, Midland, Texas, has been appointed chairman of the Midland County committee for the collection of scrap metal and rubber for the Texas petroleum industry. CHARLES F. ROESER, Fort Worth, Texas, general chairman of the oil industry's collecting campaign, made the appointment.

M. L. MAYFIELD, formerly with the Cotton Valley Operators Committee, is now a member of the natural gasoline division of the Office of Petroleum Coördinator at Houston, Texas.

J. T. FLY has been transferred from his position as head of the legal department of the Standard Oil Company of Argentina to the legal department of the Standard Oil Company of New Jersey with offices in New York, New York.

W. L. DUCKER is back in Tulsa, Oklahoma, to manage the Product Engineering Company. He has been serving as Oklahoma State manager, contact distribution branch, War Production Board.

W. E. HEIMICK has been transferred from his duties as an engineer in the field department of the Shell Oil Company at Long Beach, California, to engineer in the company's pipe-line department. He will maintain offices in Los Angeles, California.

G. E. WYNN has been made assistant general superintendent of the Mid-Continent Petroleum Corporation's refinery in West Tulsa, Oklahoma. D. G. MORGAN is general superintendent. Wynn was formerly superinterdent of the planning and development department of the corporation, having begun work with the firm in 1924 as an engineer in the gasoline department.

DAVID M. LOGAN, independent operator of Okmulgee, Oklahoma, and former head of the oil and gas committee of the house in the state legislature, has been transferred to the Office of Petroleum Coördinator from the War Production Board and is to be transferred to Oklahoma City to open an OPC office as field engineer for District 2. R. C. MITCHELL, stationed in Washington, D. C., with the Office of Petroleum Coördinator, is to be sent to Wichita, Kansas, to open an OPC office there.

R. W. BOND, production manager of the Mid-Continent area for Shell Oil Company, Inc., and a widely known Tulsa, Oklahoma, oil man, has accepted an appointment from the war department, adjutant general's office, as a specialist in the technical division of the army with the rank of major. Bond served in the first world war in the marine corps. As the company has granted Bond a leave of absence for the duration of the war, W. H. MORRISON, Oklahoma division manager, will assume duties of production manager in Bond's absence.

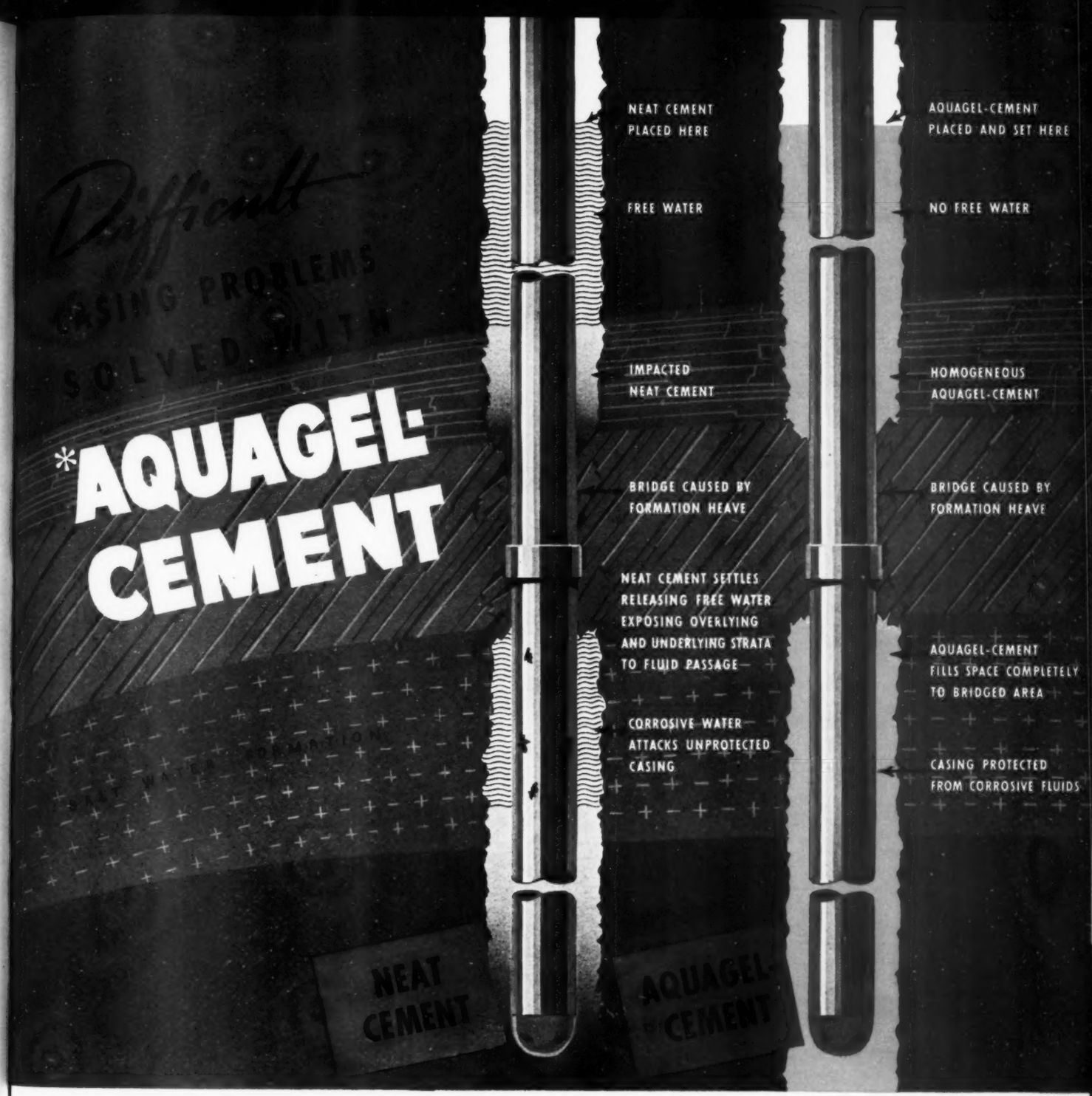
J. F. CONLEY, formerly in charge of sales in the Tulsa, Oklahoma, district for Jarecki Manufacturing Company, has been transferred to a new district at Wichita Falls, Texas. EUGENE H. BEARD, who has been city salesman in Tulsa, has been placed in charge of all sales of the Tulsa district. H. A. BRIGHTWELL, formerly in Seminole, Oklahoma, has been transferred to Tulsa as city salesman. F. G. (SID) WHITE has been transferred from Tulsa to Eldorado, Kansas. DAN WAITE of the Russell, Kansas, office of the company, has been transferred to Tulsa and made local store manager.

A. J. SMITH, field staff petroleum engineer, Texas Railroad Commission, has been transferred from Pampa to Midland, Texas, to cover the West Texas territory.

W. I. FOX, evaluation department of The Texas Company, Tulsa, Oklahoma, has been transferred to Garnett, Kansas, for work on secondary-recovery operations.

A. F. RICHARD was elected president of the Big Indian Development Company, Kansas City, Kansas, at a recent meeting of the board of directors. J. W. GARRETT was elected vice-president, and R. K. PEARSON, secretary-treasurer. HUGH B. WUNRATH, Omaha, Nebraska, is a newly elected member of the board, succeeding WALTER G. FLETT, who resigned. Reelected directors are R. F. HICKOK, W. C. HURST, HAYDEN KEMPER, W. P. KREEGER, and G. E. MCDONALD.

J. R. LEWALLEN, traffic manager for the last 8 years of the Mid-Continent Division, Tide Water Associated Oil Company, Tulsa, Oklahoma, resigned March 1 to assume duties as traffic manager of the Anderson-Pritchard Oil Corporation and Coltex Refining Company, Oklahoma City, Oklahoma. He had been with Tide Water since 1929.



Cementing casing, even under the most adverse conditions, can often be successfully accomplished with AQUAGEL-Cement. Illustrated here is one difficult problem which has been solved by this means.

In both wells a heaving stratum has sloughed, forming a bridge around each casing during, or shortly after, running of the cement. Note that the neat cement has settled below the bridge, thus exposing the casing to the injurious attack of corrosive salt water and allowing the harmful transfer of fluids between adjacent strata. The AQUAGEL-Cement, on the other hand, remains in place substantially as set, protects the casing from further sloughing, from the corrosive effects of salt water and prevents the transfer of fluids between adjacent strata.

It pays to use Baroid Products and Service in every well you drill.

PATENT LICENSES, unrestricted as to sources of supply of materials but on royalty bases, will be granted to responsible oil companies and operators to practice the inventions of any and/or all of United States Patents Nos. 1,575,944; 1,575,945; 1,807,082; 1,991,637 and further improvements thereof. Applications for such licenses should be made to Los Angeles office.

**AQUAGEL-Cement, or gel cement as it is commonly known, is any Portland or oil well cement to which has been admixed a small amount of AQUAGEL to keep it from releasing free water or allowing settling, and at the same time to impart to it sufficient gelling properties at the water-cement ratio at which it is to be used.*

BAROID SALES DIVISION • NATIONAL LEAD COMPANY

BAROID SALES OFFICES: HOUSTON • LOS ANGELES • TULSA

BAROID PRODUCTS: BAROID AND COLOX, AQUAGEL, FIBROTEX, BAROCO, STABILITE, AQUAGEL-CEMENT, SMENTOX, ZEOGEL, IMPERMEX, MICATEX, TESTING EQUIPMENT, BAROID WELL LOGGING SERVICE

LAUGH WITH BARNEY

A veterinary surgeon was instructing a farmer as to a suitable method for administering medicine to a horse.

"Simply place this powder in a gas pipe about two feet long, put one end of the pipe well back in the horse's mouth and blow the powder down his throat."

Shortly thereafter the farmer came running into the veterinary's office in a distressed condition.

"What's the matter?" asked the veterinary.

"I'm dying!" cried the farmer. "The horse blew first!"

* * *

Service Station Operator: Well, little man, what can I do for you?

Boy: My mother sent me to get change for a dollar bill, and said she would give you the dollar bill tomorrow.

* * *

Two salesmen met in a Pullman after not seeing each other for three years. "Jim," said one of them, "the defense program is speeding everything up but you still talk just as slow as ever."

"Well," said Jim, "if — you — think — I talk — slow — you — should — hear — my secretary. She — had — a date — the —other — night — and — her — boy friend — parked — on the — way — home. And — before — she — could — say — I'm — not — that — kind — of — a — girl, — she was."

* * *

"Is you de judge ob reprobates?"

"Well, Madam, I am the probate judge, if that is what you mean."

"Yas suh, dat's it, Ah 'spects. Well Mistuh Judge, it's like dis—mah husband has done died detested, and lef' me with seven little infidels, and Ah wants to be appointed as de executioner."

* * *

Recruiting Sergeant: Well, mister, are you brave in battle?

Joe: Naw suh, I runs away from the enemy.

R. S.: Why, man, that's a coward's trick.

Joe: Ah know, suh, but there's got to be somebody to pick up the brave men after the battle.

* * *

Mrs. Smith: What does your husband like best for breakfast?

Mrs. Jones: Oh, anything I don't happen to have in the house.

PRIORITY BLUES!

"Keep your temper, gentle sir," writes the manufacturer. "Though your goods are overdue for the month, or maybe two, we can't help it—please don't swear. Labor's scarce and steel is rare; can't get rivets, can't get dies; these are facts, we tell no lies.

"Johnny's drafted, so is Bill; all our work is now uphill. So your order, we're afraid, may be quite a bit delayed. Still you'll get it, don't be vexed —maybe this month, maybe next. Keep on hoping, don't say die; we'll fill your order bye and bye."

* * *

Two roughnecks out in a boat found the fishing good. Said one, "Let's mark the spot," and getting out a piece of chalk, placed an "X" on the bottom of the boat. Rowing back to shore, nothing was said until his pal pondered, "But supposin' we don't get the same boat tomorrow!"

This brings to mind the fellow at a sanitarium, who, after standing a long time at the foot of a ladder, told the painter, "Take a good hold of your brush, I'm taking the ladder away."

* * *

"The only difference between you and a horse is that a horse wears a collar."

"But I wear a collar, too."

"Then I was wrong—there isn't any difference."

* * *

She: Would you like to see where I was operated on for appendicitis?

He: No, I hate hospitals.

* * *

The Scotsman: O, hang the expense. Give the canary another seed.

* * *

It was during the impanelling of a jury that the following conversation occurred:

"You are a property holder?"

"Yes, your Honor."

"Married or single?"

"I have been married for five years, your Honor."

"Have you formed or expressed an opinion?"

"Not for five years, your Honor."

* * *

"Hey . . . where's that chicken I ordered an hour ago?"

"It'll be along soon, sir . . . the cook hasn't killed it yet, but he's getting in some nasty blows."

* * *

Walking isn't a lost art. One must, by some means, get out to the garage.

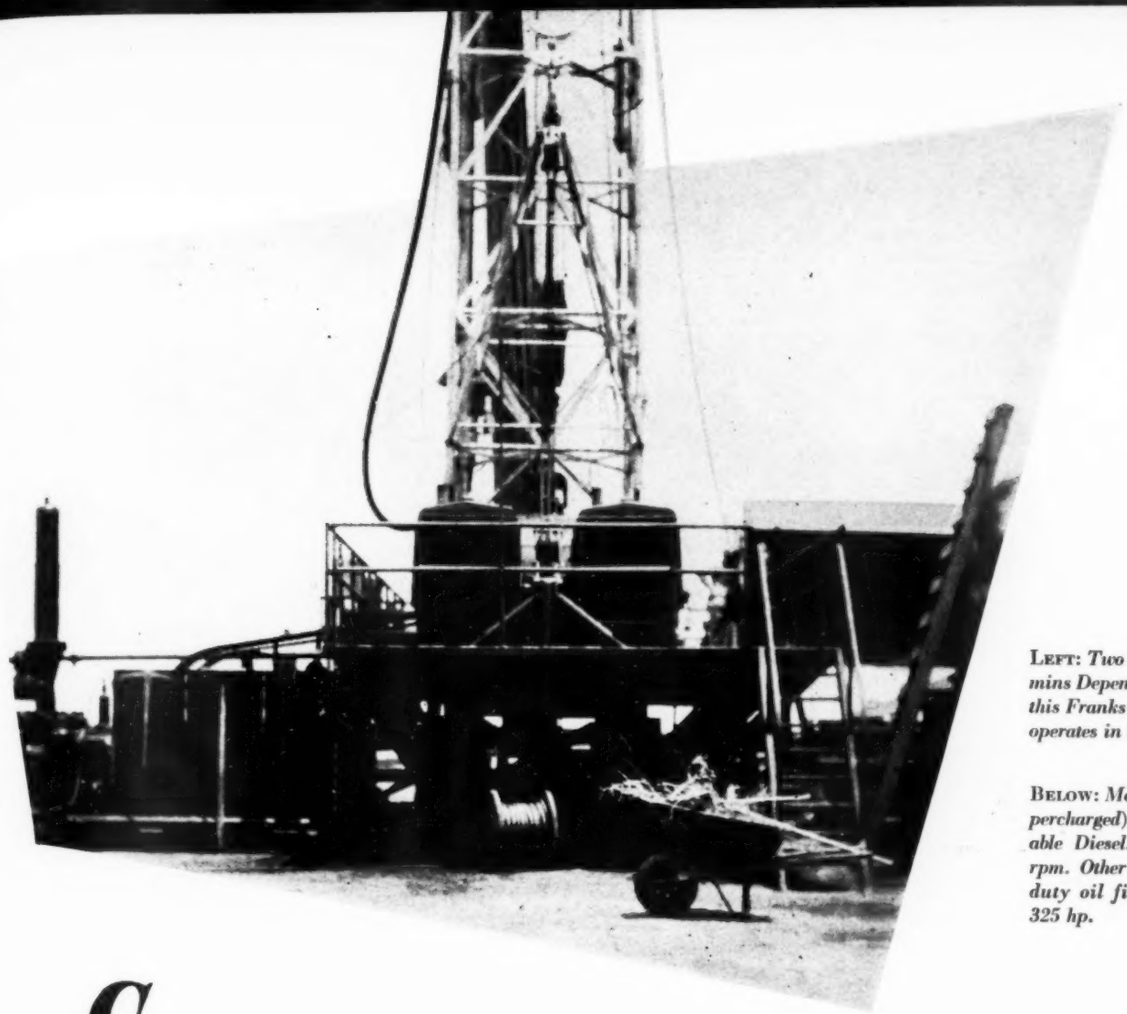
WHAT TO DO IN CASE OF AN AIR RAID

Instructions

1. As soon as bombs start dropping —RUN LIKE HELL. It doesn't matter where, as long as you run like hell.
2. Take advantage of opportunities afforded you when air raid sirens sound the attack warning . . . for example:
   (a) If in a bakery, grab some pie and cakes.
   (b) If in a tavern, grab a bottle, preferably Haig and Haig.
   (c) If in a movie, grab a blonde.
3. If you find an unexploded bomb, always pick it up and shake it like hell. The firing pin may be stuck.
4. If this doesn't work, heave it in the furnace. (The Fire Department will come later and take care of things.)
5. If an incendiary bomb is found burning in a building, throw some gasoline on it. You can't put it out anyhow, so you might as well have some fun.
   (a) If no gasoline is available, throw a bucket of water on it and lie down—you're dead.
   (b) The properties of the bomb free the hydrogen from the water, causing rather rapid combustion, in fact, it will explode with a helluva crash.
6. When you hear the alarm, run like hell for any crowded place; everyone knows there is safety in numbers.
7. Always get excited and holler bloody murder. It will add to the fun and confusion and scare hell out of the kids.
8. Drink heavily, eat onions, limburger cheese, etc., before entering a crowded air raid shelter. This will make you unpopular with the crowd in your immediate vicinity, eliminating any unnecessary discomfixture that would be more prevalent if people crowded too closely.
9. If you should be the victim of a direct bomb hit, don't go to pieces; lie still and you won't be noticed.
10. Knock the air raid wardens down if they start to tell you what to do. They always save the best seats for themselves and their friends.
11. When the raid is over, if in a private shelter, leave there as quickly as possible; her husband may be home any minute.

* * *

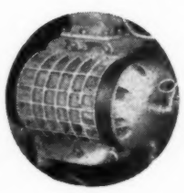
Peter, Peter, pumpkin eater
Had a wife and couldn't keep her
Cutest little clinging vine
But she believed a driller's line.



LEFT: *Two supercharged Cummins Dependable Diesels power this Franks skid-type rig which operates in a West Texas field.*

BELOW: *Model HBIS-600 (supercharged) Cummins Dependable Diesel. 200 hp. at 1800 rpm. Other models for heavy-duty oil field service, 33 to 325 hp.*

SUPERCHARGED... for SUPER Jobs



SUPER JOBS . . . jobs that demand more than ordinary performance from the engine . . . jobs that must have maximum output with a minimum of space requirements . . . jobs where the elimination of every pound of useless weight is vital to assure a portable unit that can be moved and set up quickly. . . . SUPER jobs where the need to "make time" dictates the use of a proved engine with which to guard against delays or interruptions for service or parts replacement. These are the kind of jobs that call for the Cummins Supercharged Diesel . . . the diesel that has proved itself equal to every demand in the oil fields—drilling, pumping, generating . . . doing these SUPER jobs on 24-hour schedules with dependable regularity.

And because America needs so many of these proved diesels for its super war-time job, it is increasingly difficult to supply Cummins Dependable Diesels for even the most important commercial use but remember: only by completing this tremendous job before us, surely and quickly, can we be assured of future jobs to do . . . and *better* engines with which to do them. Cummins Engine Company, Columbus, Indiana.

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Distributors Mid-Continent Territory

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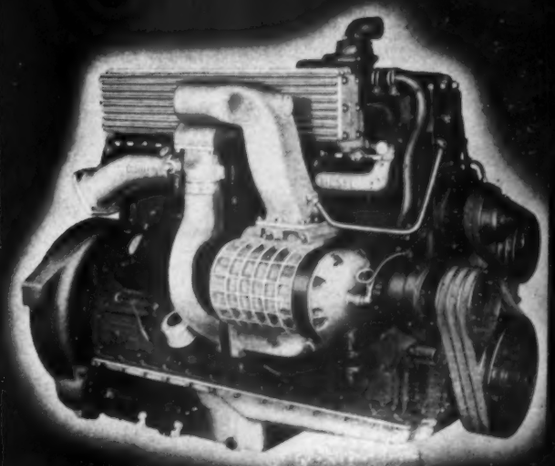
Dependable
DIESELS



Supplemental Order No. 1 to M-68

The following was released February 13 by OPC:

"The pressing demand of war industries in certain parts of the Appalachian region for larger quantities of locally-produced natural gas will be met by the action relaxing the application of the 640-acre gas well-spacing provision of Conservation Order M-86, it is announced by Petroleum Coordinator Harold L. Ickes.

"Aid to operators in supplying the heavy and increasing industrial requirements is provided under Supplementary Order No. 1 to M-68, issued by the War Production Board on recommendation of the Office of Petroleum Coordinator. As a result of the supplementary order, natural gas producers in the states of New York, Pennsylvania, West Virginia, Ohio, and Kentucky now will be able to obtain materials for new wells drilled to a uniform spacing pattern of one well to 160 surface acres, for certain horizons, and one well to 40 surface acres for other horizons.

" 'It is believed that this action will temporarily assure the quantities of gas necessary for the important war industries in Cleveland, Pittsburgh, Youngstown, and other cities,' said Deputy Coordinator Ralph K. Davies.

"The supplement was recommended by the Coordinator's Office following a study made by the Natural Gas and Natural Gasoline Committee for District 1, headed by J. French Robinson of Cleveland. The Office was informed, moreover, that Army and Navy officials are in full accord with the provisions incorporated in the supplementary order and were eager that they be issued so that a maximum supply of locally-produced natural gas may be assured for the remainder of the year.

"Under its terms, paragraph (b) of M-68 has been amended so that operators in New York, Pennsylvania, West Virginia, Ohio, and Kentucky may obtain materials to drill, complete, or provide additions to any well drilled in conformity with the spacings provided in the order.

"Wells drilled to the Onondaga Limestone, Oriskany Sandstone, or Devonian Shale horizons must conform to a uniform spacing pattern of not more than one well to each 160 surface acres. Wells drilled to sands or horizons other than those previously named must conform to a pattern of not more than one well to each 40 surface acres.

"Wells qualifying under the 160-acre provisions, however, cannot be spudded unless:

"1. The drilling unit on which the well is located consists entirely of acreage not attributable to any other well.

"2. No portion of the drilling unit falls within 660 ft. of an existing well.

"3. All separate property interests of less than 160 acres, or in tracts on which a well cannot be drilled in conformity with the terms of the supplementary order, are consolidated to form a drilling unit of not less than 160 acres.

"4. Such well is drilled at least 1980 ft. from all wells spudded after December 23, 1941.

"5. Such well is drilled at least 990 ft. from all wells spudded or completed on or before December 23, 1941.

"6. Such well is drilled at least 660 ft. from any lease, property, or subdivision line that separates unconsolidated property interests.

"Wells qualifying under the 40-acre provision cannot be spudded unless:

"1. The drilling unit on which the well is located consists entirely of acreage not attributable to any other well.

"2. No portion of the drilling unit shall fall within 330 ft. of an existing well.

"3. All separate property interests of less than 40 surface acres, or in tracts on which a well cannot be drilled in conformity with the terms of the supplementary order, are consolidated to form a drilling unit of not less than 40 surface acres.

"4. Such well is drilled at least 990 ft. from all wells spudded after December 23, 1941.

"5. Such well is drilled at least 660 ft. from all wells spudded or completed on or before December 23, 1941.

"6. Such well is drilled at least 330 ft. from any lease, property, or subdivision line that separates unconsolidated property interests."

Amendment No. 3 to Order M-68

1047.1 Conservation Order No. M-68 is hereby amended by inserting after paragraph (c) thereof a new paragraph (d) as follows, and relettering the ensuing paragraphs accordingly:

(d) Determination of uniform well-spacing pattern

(1) Subject to the provisions of (2) below, each well "spudded" subsequent to December 23, 1941, in any oil or gas field, other than a condensate field, on any proposed drilling unit consisting of not less than 40 surface acres in the case of any oil field or of not less than 640 surface acres in the case of any gas field, shall be deemed to conform to a "uniform well-spacing pattern" for the purpose of paragraph (c) (7) and (8) hereof, where such well is drilled in accordance with the following terms:

(i) Each well shall bear the same geographical relationship with respect to the square drilling unit upon which it is to be located as all other wells drilled subsequent to December 23, 1941, bear to the respective square drilling units upon which such wells have been or are to be located; Provided, that subject to the provisions of (2) below, any well that is to be drilled shall be considered as conforming to a uniform well-spacing pattern where such well is to be located within 100 ft. of the point at which absolute geographic identity would be attained or where such well is to be located within 150 ft. of the geographic center of a square drilling unit; or

(ii) Where property interests (including lease-hold or other property interests) in irregularly shaped tracts necessitate departures from square drilling units, a well may be located on any drilling unit consisting of not less than the prescribed number of surface acres (40 surface acres in the case of an oil field; 640 surface acres in the case of a gas field); Provided, that such well is drilled in conformity with the provisions of (2) below.

(2) No well "spudded" subsequent to December 23, 1941, shall be considered as drilled in conformity with a uniform well-spacing pattern unless:

(i) The proposed drilling unit upon which such well is to be located consists entirely of acreage that is not attributable to any well other than such proposed well. The acreage attributable to wells offsetting the proposed drilling unit shall be determined by assigning to such wells an acreage equivalent to that in the existing well density or drilling pattern contiguous to such wells. In the case of an oil field no portion of a drilling unit shall fall within 330 ft. of an existing well; in the case of a gas field no portion of a drilling unit shall fall within 1320 ft. of an existing well; and

(ii) The direct linear distance between any two points that are farthest removed from each other on the drilling unit upon which a well is to be drilled does not exceed the length of the diagonal of a rectangle whose length is twice its width and which is equivalent in surface acreage to such drilling unit; and

(iii) All separate property interests of less than 40 surface acres in the case of an oil field, 640 surface acres in the case of a gas field, or in tracts on which a well cannot otherwise be drilled by virtue of the provisions of this order, surrounding the designated drilling location of any well, are first consolidated with each other, another, or other property interests to form a drilling unit (consisting of not less than 40 surface acres in the case of an oil field; 640 surface acres in the case of a gas field) on which a well may be drilled; and

(iv) Such well is drilled at least 990 ft. in the case of an oil field or 3960 ft. in the case of a gas field from any well "spudded" in such field subsequent to December 23, 1941; and

(v) Such well is drilled at least 660 ft. in the case of an oil field or at least 2640 ft. in the case of a gas field from any well "spudded" or completed in such field on or before December 23, 1941; and

(vi) Such well is drilled at least 330 ft. in the case of an oil field or 1320 ft. in the case of a gas field from any lease line, property line or subdivision line which separates unconsolidated property interests.

This amendment shall take effect immediately.

Issued this 18th day of February, 1942.

J. S. Knowlson,
Director of Industry Operations.

Countersignature of A-8 and Lower Under P-98 Waived

Operators of petroleum enterprises are relieved of the necessity of obtaining a countersignature from field representatives of the Office of Petroleum Coordinator when using preference ratings of A-8 or lower to obtain repair, maintenance, and operating supplies with a value of less than $500 by Amendment No. 1 to Preference Rating Order P-98, announced February 21 by the Director of Industry Operations.

The announcement states:

"The countersignature of a field official must still be obtained when the preference ratings assigned by P-98 are used on any order amounting to more than $500, or on any order for material to be used for new facilities.

"Specific permission to use any rating of A-2 or higher must be obtained from the Office of Petroleum Coordinator in Washington unless the material is to be used for research or laboratory purposes.

"Preference Rating Order P-98 assigns priority ratings from A-1-a to A-10 for deliveries of materials to be used for specified purposes in the production, refining, transportation, and marketing of petroleum and petroleum products. As the order was originally issued, these ratings could be used only upon telegraphic authorization from Washington, or when orders were countersigned by field officials of the Office of Petroleum Coordinator. Today's amendment will permit the use of the lower ratings without countersignature on orders from maintenance, repair, and operating supplies when the amount involved is less than $500."

Amendment No. 1 to Order No. P-98

(a) Section 1041.1 [Preference Rating Order No. P-98, paragraph (e) (2)] is hereby amended to read as follows:

(2) In addition to the requirements of paragraph (e) (1), the operator (but not a supplier), in order to apply any of the preference ratings of A-2 or higher assigned by paragraph (b) of this order, other than ratings assigned by paragraphs (b) (1) (ii) and (b) (2) (iv) hereof, must communicate with the Office of Petroleum Coordinator, Washington, D. C., Ref.: P-98 supplying in detail the following information:

(i) date of actual breakdown or suspension of operations (if applicable);

(ii) the equipment to be repaired and its operating importance (if applicable);

(iii) the material and quantity thereof necessary to effectuate the repair or to initiate or maintain operations;

(iv) the supply of the necessary material which the operator has on hand or available; and

(v) the names and addresses of suppliers from whom the material is to be obtained and the earliest delivery dates assured by any such supplier for delivery of the minimum necessary quantity of material.

The Director of Industry Operations will notify the operator whether, and to what extent, the application is approved. A copy of such notification shall be furnished by the operator to any supplier to evidence the proper rating granted pursuant to the provisions of this order.

(b) Section 1041.1 [Preference Rating Order No. P-98, paragraph (e) (3)] is hereby amended to read as follows:

(3) In addition to the requirements of paragraph (e) (1), the operator (but not a supplier), in order to apply any preference ratings, other than those of A-2 or higher assigned by paragraph (b) of this order, must obtain the countersignature of the director in charge of the nearest district office of the Office of Petroleum Coordinator upon the purchase order which such supplier has endorsed and signed pursuant to paragraphs (e) (1); unless,

(i) any completely fabricated, individual item to which a preference rating is to be

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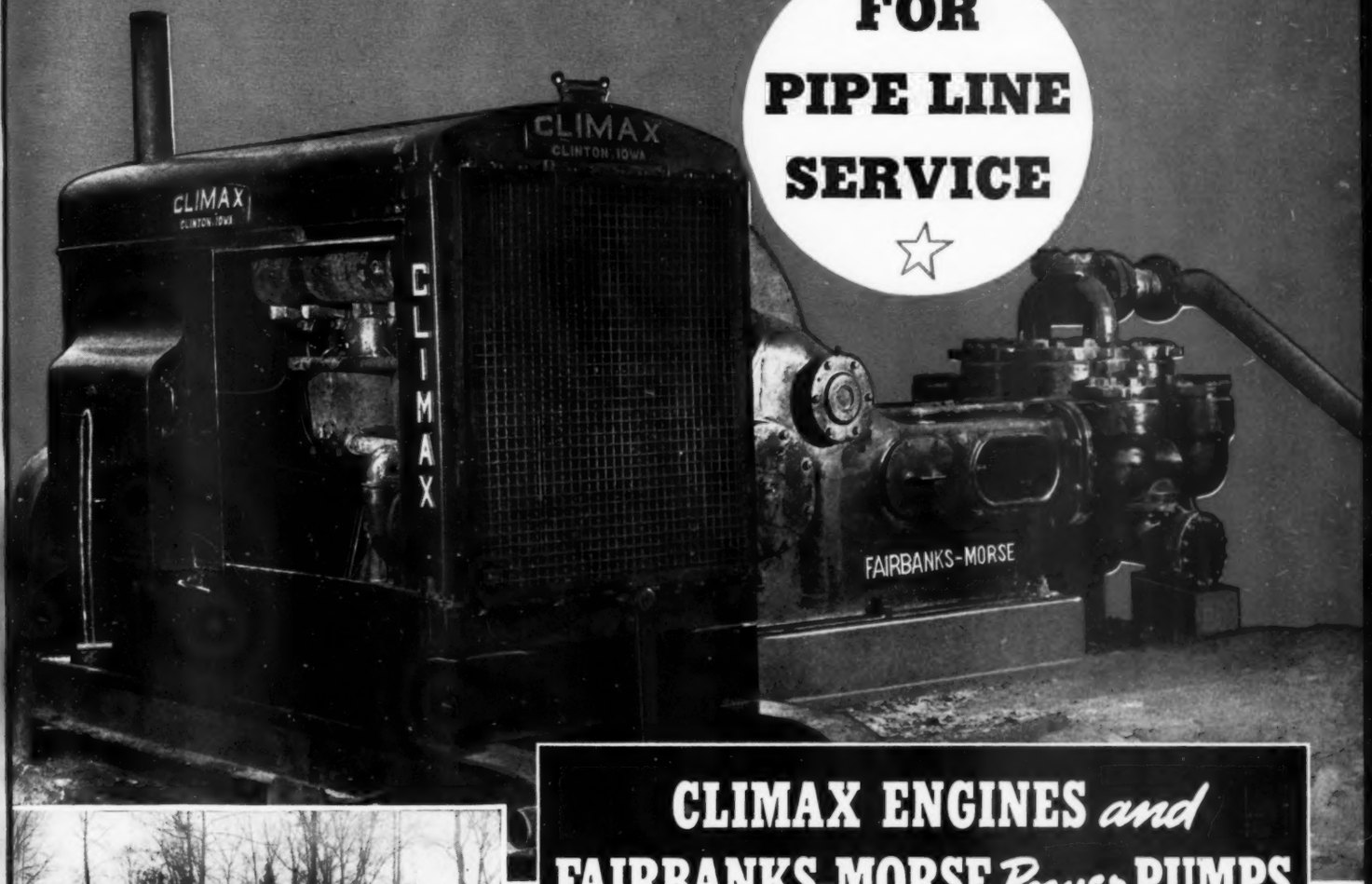

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applied has a cost to the operator of $500 or less; and

(ii) the rating which is to be applied in obtaining delivery of such an item is assigned by paragraphs (b) (1) (iv); (b) (2) (v), (vi) or (vii); (b) (3) (ii), (iii) (iv); or (b) (4) i) or (ii).

(c) This amendment shall take effect immediately.

Issued this 20th day of February, 1942.

J. S. Knowlson,
Director of Industry Operations.

Priority ratings under P-98

Attention is called to the fact under Section (e) (2) of P-98, it is necessary that the oil companies answer the following five questions:

(1) Date of actual breakdown or suspension of operations (if applicable);
(2) The equipment to be repaired and its operating importance (if applicable);
(3) The material and quantity thereof necessary to effectuate the repair or to initiate or maintain operations;
(4) The supply of the necessary material that the operator has on hand or available; and
(5) The names and addresses of suppliers from whom the material is to be obtained and the earliest delivery dates assured by any such supplier for delivery of the minimum necessary quantity of material.

To obtain any of the following ratings:

Production
Paragraph (b) (1) (i)—Rating of A-1-e
(b) (1) (iii)—Rating of A-2

Refining
Paragraph (b) (2) (i)—Rating of A-1-a
(b) (2) (ii)—Rating of A-1-c
(b) (2) (iii)—Rating of A-2

Transportation
Paragraph (b) (3) (i)—Rating of A-2

Answering these questions by numbers and repeating the question will facilitate consideration by OPC and WPB.

Shipments Casing, Tubing, Drill Pipe, Line Pipe, Require A-9 or Higher

The following was released by WPB February 23, 1942:

"Steel producers supplying the petroleum industry have been ordered by telegram from the Director of Industry Operations not to ship oil country casing, tubing, or drill pipe on or after March 14, or to ship line pipe on or after March 7 except on orders bearing a preference rating of A-9 or higher.

"Warehouses which purchase this type of goods are entitled to use a preference rating of A-9 under Supplementary Order M-21-b, and oil companies may use an A-8 rating under Preference Rating Order P-98. The purpose of the telegraphic order is to prevent shipments of steel for use in the petroleum industry on unrated orders, and thus to make sure that the limitations applying to the industry are observed, including limitations on inventories."

Interior Department Program For Petroleum During War

A seven-phase plan of activity to serve in mobilizing strategic natural resources of the Nation was announced as the war program of the Department of Interior February 23, by Secretary Harold L. Ickes.

Conversion of all bureaus and divisions of the Department to function as coordinated units of a federal wartime agency is being completed. Activities that were considered desirable in peacetime, and which now are vital in war, have been accelerated. Other activities, essentially peacetime in character, have been subordinated to these war efforts.

The Department's program aims to make possible the supplying of the essential metals, oil, power, fuel, helium, food, land, water, and timber for war. A total of 52 distinct proposals of recommended actions are listed.

Secretary Ickes pointed out that the long experience of the Department in conserving the Nation's resources for the time of need will now ease the task of turning them to the supreme effort. At the same time, it will protect the resources themselves from foolish, shortsighted, or wasteful exploitation. The program was evolved by the War Resources Council of the Department in fulfillment of a departmental order written on December 7, 1941, which declared that the Department's "immediate and primary function is the full mobilization of the Nation's natural resources for war."

The portion of the program relating to oil follows:

Oil for war

Without petroleum products, the war machine which the United States and the United Nations are now perfecting could not function. National petroleum production must be increased by the most efficient methods to fill mounting requirements. The production and operation of mechanized armies, self-propelled artillery, substratosphere bombers, and multiple-ocean navies require unfailing supplies of high-quality gasoline and lubricants and other oil products. The expanding industrial second line of defense and the third front at home also must be supplied. To meet the requirements, United States production may have to be raised to 1,500,000,000 bbl. of oil a year.

Preparations to meet the challenge were made through the Office of the Petroleum Coordinator, which was established seven months before Japan made the Pacific a misnomer for the western ocean.

The Department proposes:

(1) To organize petroleum production based upon sound engineering techniques so that operating wells and fields can produce at sustained rates without injury to our remaining reserves and so that the crude oils, condensates from high-pressure fields, and natural gasolines needed for aviation gasoline and lubricants, toluene, synthetic rubber, and other specialized products will be available in the quantities required when needed; to stimulate exploration for new reserves, and, through cooperation with state regulatory bodies, to leave in safe underground storage those crude oils not immediately important to the war effort. (Office of the Petroleum Coordinator.)
(2) To multiply the industry's capacity to manufacture high-octane gasoline for war planes to as much as 200,000 bbl. per day; to stimulate the financing and erection of 100-octane plants; to control closely the aviation gasoline supply to insure its appropriate use; to organize the natural gas and natural gasoline industries to meet plant fuel requirements and to obtain the maximum production of the components of aviation gasoline, as well as rubber and other synthetic products, and to stimulate the production of aviation lubricants. (Office of the Petroleum Coordinator.)
(3) To establish new and more effective transportation methods required in moving blending stocks for aviation gasoline; to reshape the complex transportation system of the oil industry by substituting tank cars, trucks, barges, and pipe lines for tankers diverted to war service. (Office of the Petroleum Coordinator.)
(4) To formulate and, if needed, to direct marketing programs to insure the best distribution of available supplies for civilian uses in the event of the disruption of normal deliveries; to coordinate marketing and distributing facilities so as to maintain inventories, and to find and obtain petroleum products for use by the armed forces, essential industries, and civilian activities if normal channels of procurement do not bring about the necessary results. (Office of the Petroleum Coordinator.)
(5) To formulate plans for the manufacture of essential components of synthetic rubber from petroleum products, including butadiene and styrene; and to stimulate expansion of plant capacity for the manufacture from petroleum of toluene for explosives. (Office of the Petroleum Coordinator.)
(6) To engage in an active geological exploration campaign with a view to determining all possible areas in which prospective drilling for new deposits of petroleum and natural gas may be successful. To promote and encourage exploratory operations on lands owned or controlled by the United States having potential value for petroleum products; to take steps to insure adequate and proper development of known reserves on such lands, and to cooperate with industry and state authorities in attaining these objectives where such lands are interspersed with lands not under exclusive federal control. (Geological Survey.)
(7) To make available to the petroleum industry the latest developments in technical methods, practices and procedures in the production, handling, transportation, and storage of petroleum and its products; to make available fullest technical guidance in the protection of petroleum in storage against deterioration, contamination, fire, or sabotage and other hazards; to keep the industry fully advised as to the trends of demands and requirements in order that it can gauge its necessary operations in advance so that the supply of products may be continuously available where, when, and as needed. To conduct all of these activities in such a manner as to bring all units of the petroleum industry, large and small, into the war program; and to execute that program so that no unnecessary dislocation of competitive positions in the industry, or hardship to the general public, shall occur. (Office of the Petroleum Coordinator, Geological Survey, U. S. Bureau of Mines, Petroleum Conservation Division.)

East Texas Pressure Drop Alarms Ickes

The following was released by OPC February 20, 1942:

"Petroleum Coordinator Harold L. Ickes called today for positive measures directed at the prevention of further excessive pressure drops in the East Texas oil field.

"Informed by Texas Railroad Commissioner Jerry Sadler, in a conference Wednesday, that bottom-hole pressure in the field dropped an alarming 15.85 lb. in January alone, the Coordinator said the need for remedial action was immediately imperative in the interest of the war effort.

" 'I am greatly concerned for the future of the East Texas field,' Coordinator Ickes said in a statement.

" 'It is the Number 1 source of oil in the United States, containing 10 percent of the national reserves of crude petroleum. So important is it, in fact, that it may well be considered as our factor of safety in supplying the Nation's petroleum requirements for the duration of the war.

" 'Yet, the future of this vital field is being seriously menaced by the increased production of salt water, as a result of which the resorvoir pressure declined dangerously in January. This and previous drops have brought the pressure down so low that it is close to the point of being insufficient to maintain the natural flow of wells.

" 'There is imperative need for immediate action to remedy a condition, which, if it is allowed to continue, cannot but result in permanent injury to us in our ability to supply the needs of our armed forces and war industries for petroleum.

" 'I commend this problem to the attention of the Texas Railroad Commission.'

"The Coordinator said he had discussed ways and means of correcting the situation with Sadler."

Amends California Plan

The Office of Petroleum Coordinator on March 9 announced amendment of the California conservation plan to stop the production of oil or gas from wells in that state upon which materials have been installed or used in violation of Conservation Order M-68 of the War Production Board.

The action was taken at the specific request of the industry Production Committee for District 5 (Pacific Coast).

The amendment — to Coordinator's Recommendation No. 19, under which the California plan operates—grants specific authority to the Production Committee to refuse to establish allowables for wells upon which equipment has been installed illegally. When taken in conjunction with prohibitions already incorporated in the recommendation, this means not only that the owners of such wells will be prohibited from producing any oil or gas from them, but that transporters and purchasers will be prohibited from either transporting or purchasing any such oil or gas.

Prompting issuance of the amendment was a report from the production committee of several instances of alleged violation of Conservation Order M-68, which prohibits the use of critical materials for production of oil except under certain specified conditions.

To Allocate Tanker Space

Formal approval of a plan that provides for the equitable allocation of available tanker space for movement of oil to the East Coast has been announced by the Office of Petroleum Coordinator Harold L. Ickes.

The plan was developed by the industry transportation committee for District 1, acting on authority of the Coordinator (under his Recommendation No. 36) and is designed to mitigate some of the conditions resulting from the disruption of water-borne shipments of petroleum and petroleum products into the area since the outbreak of the war.

When placed in actual operation, sometime within the next few days, it will provide the means whereby participants will be assured a percentage of available tanker space in proportion to their use of this transportation method between July 1, 1939, and June 30, 1941.

Subject to certain specified conditions, the "benefits and burdens" of the plan are open to any refiner, marketer, or consumer of crude oil or products in District 1 who chooses to participate. The conditions are:

(1) Each shipper participant must share its proportionate part of the excess cost of transporting oil to the East Coast by alternate means of transportation—by rail, pipe line, barge, and tank truck—in accordance with cost-sharing arrangements already authorized by the Petroleum Coordinator.
(2) No participant may withdraw from the plan prior to its termination or prior to the end of the first 15 months of its operation.

Carrier participation in the plan will be at their own election and is limited to owners and operators of tankers in excess of 3000 registered gross tons.

A Tanker Managing Subcommittee, with headquarters in the RCA Building, New York City, and headed by C. H. Kunze of the Socony-Vacuum Oil Company, will administer the program. This committee is now developing the procedure to be followed.

The function of the committee will be that of allocating the carrying capacity of tankships among shipper participants on a certified percentage basis, and of directing the movements of vessels. Shipper participants will be entitled, however, to retain control over the movements of any vessel owned or operated by them within the limits of their allotted tonnage.

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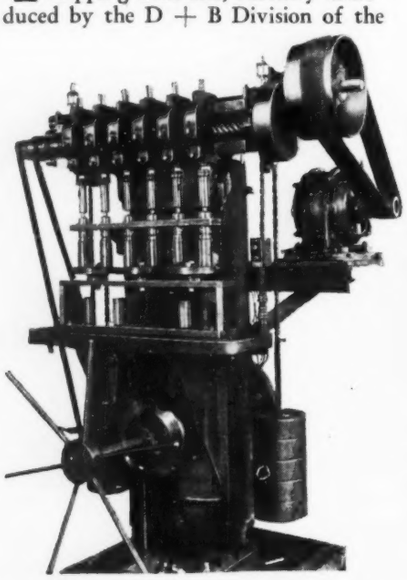
MACHINERY and EQUIPMENT

Improved Rotary Mud Gun

AS an improvement to their safety mud gun, engineers of Patterson-Ballagh Corporation have added a safety latch and have streamlined the flow of mud through the gun to eliminate an abrupt curve. The improved gun has a long swing ell and its main casting is of heavy steel. A locking ring provides for vertical adjustment. A new spring latch permits horizontal locking without the necessity of unbolting. This gun can be equipped with an extended pipe and a rubber nozzle. Details may be obtained from Patterson-Ballagh Corporation, 1900 East 65th Street, Los Angeles, California.

New Machine Assures Perfect Shoulder Contact for Sucker-Rod Couplings

THE new Automatic Coupling Lapping Machine, recently introduced by the D + B Division of the Emsco Derrick and Equipment Company, is designed to impart a greater degree of accuracy to the faces of D + B Sucker-Rod Couplings.



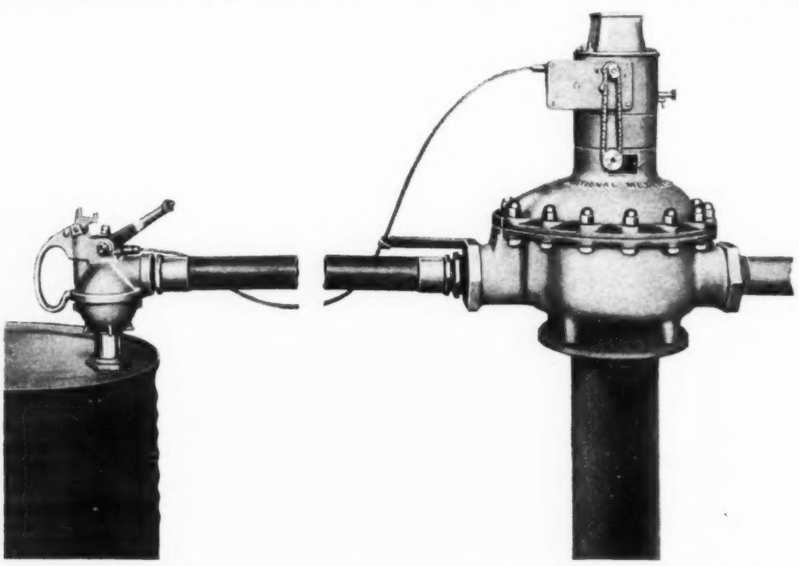
This new lapping process is an additional operation and does not replace any of the former steps for truing coupling faces. The coupling faces are precision ground, as before, but are extra processed in the lapping machine. This finishes them with the high degree of accuracy so necessary for the economical and efficient operation of the rod string.

Lapping assures perfect smoothness on the coupling faces. Uniform contact between the coupling faces and the shoulder of the sucker rod pins makes a more positive joint and better alignment of the entire rod string. Pin failures due to eccentric loading are eliminated and a friction locking effect reduces the possibility of unscrewing, the manufacturer states.

Empire Thermostatic Drum Filler

ANNOUNCEMENT has been made by the National Meter Division of the Pittsburgh Equitable Meter Company of the newly designed Empire Thermostatic Drum Filler.

This unit consists of: (1) An Empire oscillating piston, positive displacement meter, (2) a thermostatic microset for automatically correcting the meter measurement to the exact equivalent of the desired volume at 60°F., (3) a repeat register with exterior quantity chain having a fixed cam thereon that trips, and (4) a mechanically operated control valve with nonfoaming, dripless nozzle of integral construction.

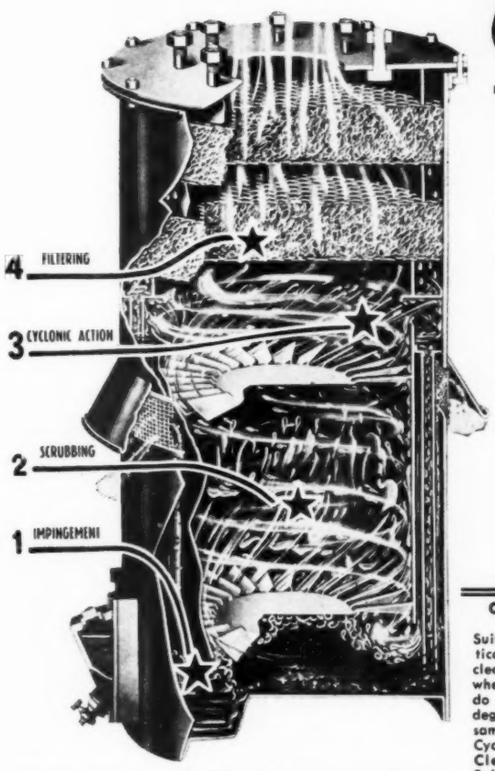


It is stated that changing from one predetermined delivery amount to another is accomplished by simply installing a quantity chain of the proper length on the side of the repeat register. Quantity chains in lengths of from 10 to 100 gal. per cycle can be provided.

The manufacturer asserts that the use of this unit will result in a 100 percent increase in barreling speed over the measure by weight method. It eliminates constant thermometer checking, reference to complicated charts and calculations, and requires no setting and resetting of adjustments for temperature changes.

A new bulletin, N-603, has been issued completely describing the Empire Thermostatic Drum Filler. To obtain a copy, address the National Meter Division at 4207 First Avenue, Brooklyn, New York.

Cycoil CLEANERS WILL KEEP THEM RUNNING *PERFECTLY* LONGER!



Write for Cycoil Bulletin No. 130D which gives complete information on the operation of the Cycoil.

Today—more demands are put on engines than ever before—they *must* run more hours per day—*must* give more years of service! That's why *clean air* is vital to your engine operation. Originally engineered to meet the extreme conditions of the dust bowl areas, *Cycoil* air cleaners not only give outstanding performance under all conditions, but are effective as intake silencers on both engines and compressors.

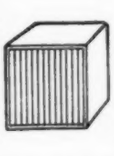
Engine manufacturers know *Cycoil's* exclusive 4-way cleaning assures positive dust protection. They will be glad to equip *your* new engines with *Cycoil* cleaners and you pay only a little more for the best.

Write for facts on how *Cycoils* save money, keep engines running *perfectly* longer! There is an American Air Filter for every engine and compressor requirement. Send *today* for full information.

AMERICAN AIR FILTER COMPANY
INCORPORATED
384 Central Ave., Louisville, Kentucky, U. S. A.
In Canada: DARLING BROS, Ltd., Montreal, Canada

CYCOIL GAS CLEANER
Suitable for practically every gas cleaning problem when temperatures do not exceed 140 deg. F. Operates on same principle as Cycoil Oil Bath Air Cleaner. Ask for Bulletin 130D.

PL-H FILTER
is a complete assembly consisting of housing, ready to bolt to intake pipe, and dry cell type filters in which wool felt constitutes the filter medium. Ask for Bulletin 120D.



TYPE OCH FILTER
Complete assembly consisting of washable viscous impingement type filters. 1, 2, 3, or more cells are used, depending upon size of cleaning job. Ask for Bulletin 120D.

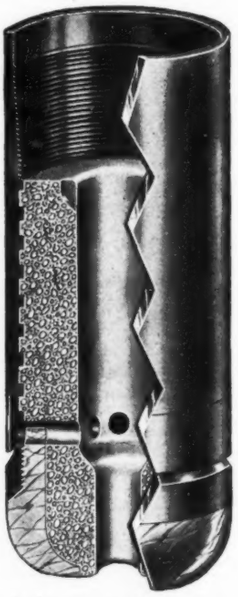
AMERICAN *Cycoil* AIR and GAS CLEANERS

Larkin Geyser Guide Shoe and Float Shoe

LARKIN Packer Company, St. Louis, Missouri, has introduced the geyser principle of fluid action as an improvement in side-opening guide shoes and float shoes as a result of a long period of research and development to prove the value of this feature in guiding, floating, and cementing equipment.

The geyser design represents an improved side opening that delivers approximately 60 percent of the fluid at a 30-deg. downward angle through the side outlet. This jetting action of slurry is evenly distributed around the entire circumference of the shoe and the motion thus provided has been found to thoroughly clean the wall of the hole at the point of jet impingement, the manufacturer states. By slowly raising and lowering the casing prior to and during the cementing operation the user is able to clean the well bore of mud cake, and thus assure a better cement job, it is pointed out.

The manufacturers supply geyser guide shoes and geyser float shoes having an upward motion of slurry rather than the downward motion when the upward motion is preferred. The geyser design is such that not only does the method of baffling the ports in this shoe reduce to a minimum the possibility of an uneven distribution of slurry due to clogged side-ports, but



Larkin Geyser Guide Shoe

Larkin Geyser Float Shoe

even if a port should become clogged the action of fluid passing through the other ports would quickly wash-out obstructing matter, it is stated.

The knife-like jetting action provided by the geyser type shoes not only is recommended by the makers for washing down restricted or bridged holes, but for cutting away and circulating from the hole the mud cake always present on the face of the porous producing formations. Removal of this mud cake facilitates a more satisfac-

Here are oilfield engines built for even greater endurance than prior Case models with records of running year after year in 24-hour duty at amazingly low upkeep. Equipped with automatic cut-outs which shut down if engine temperature goes up or oil pressure goes down, they protect themselves against mishap and neglect. Extra-well guarded against dust by Case-built air cleaner and long-life shaft seals, they resist wear better than ever before. Ask distributors or write factory for full information on new models "DE" and "LAE," 35 and 55 H.P. J. I. Case Co., Racine, Wis.

CASE
Oil Field Engines

DISTRIBUTORS
Southwest Equipment Co.
Dallas and Kilgore, Texas
Leland Equipment Co.
Tulsa, Oklahoma

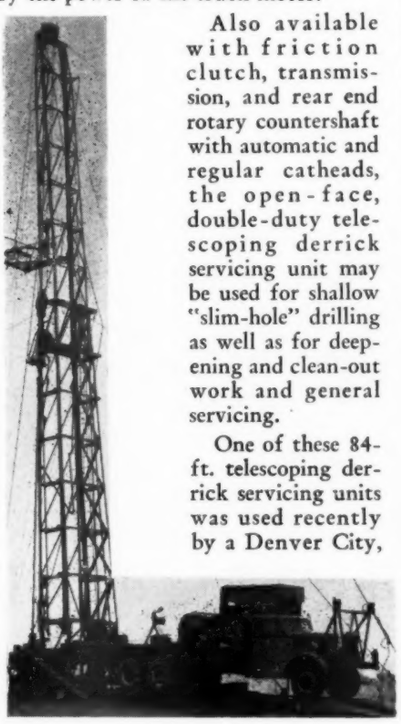
tory and successful cementing job.

Greater strength in both the new geyser guide and float shoes is derived from strict adherence to the exclusive Larkin shock-proof fabric-base Bakelite design, it is stated. The geyser float shoe is equipped with the regular Larkin ball-type back-pressure valve. Precision machining used in the back-pressure valve makes it leak-proof under both high and low pressures without the use of any other material than the exclusive Larkin fabric-base Bakelite.

For more complete details address Larkin Packer Company, 6200 Maple Street, St. Louis, Mo.

Telescoping Derrick Servicing Unit

A UNIT capable of various types of jobs is the Franks Manufacturing Corporation's portable telescoping derrick servicing unit, which is shown with a rotary drive attachment for use in actual drilling operations, driven by the power of the truck motor.



Also available with friction clutch, transmission, and rear end rotary countershaft with automatic and regular catheads, the open-face, double-duty telescoping derrick servicing unit may be used for shallow "slim-hole" drilling as well as for deepening and clean-out work and general servicing.

One of these 84-ft. telescoping derrick servicing units was used recently by a Denver City, Texas, drilling contractor to complete a total of 58 jobs within a 12 months' period, including 16 cleanouts, 11 deepenings, 10 following up rotaries, and 21 running tubing. This derrick folds down over the truck to a length of 54 ft. for over-the-road travel.

Main features of this Franks designed and constructed unit include: 100 percent portability; line and blocks carried strung; patented mechanical raising and lowering device; derrick raised by power to drive hoist; raises in seven minutes to save rig-up and tear-down time; requires only four guys at the derrick top; rotary attachment available; open face design; can be left standing full of tubing in the field while the hoist is being used with other equipment.

For additional information write Franks Manufacturing Corporation, Tulsa, Oklahoma.

Hose Made With Synthetic Rubber

AN added construction for its Type 400SS oil hose, with elimination of all natural rubber and substitution of its own synthetic rubber, Ameripol, is announced by The B. F. Goodrich Company, Akron, Ohio.

This type hose is also made with an Ameripol synthetic rubber tube, but with the cover and rubber used to impregnate the body plies of natural rubber. The new design incorporates Ameripol in every part of the hose.

All the hose is thus made resistant to the action of oils, gasolines, or other solvents of natural rubber. New construction also affords stronger adhesion of all parts with an additional margin of safety against ply separation, the manufacturer asserts.

Manila Rope is Scarce

SAVE IT

By Using TITAN Ball Bearing Catline Swivels

TITAN Ball Bearing Catline Swivels are made from high-grade alloy steel, properly heat treated, in three types of two sizes each, 25,000 and 35,000 pounds strength, respectively. They prevent twist in line and therefore lengthen life of lines. Note the specific advantages of each.

TYPE A

Type A can be assembled on rig or in supply store with wire rope which already has thimble spliced in it. No. 1-A takes 1" or 1⅛" Manila rope in one end and ⅜" or ½" wire rope *with thimble* in other end. No. 3-A takes 1¼" or 1½" Manila rope in one end and ½" or ⅝" wire rope *with thimble* in other end.

TYPE B

On Type B your wire rope must be either spliced on the job or fastened with wire line clamps. No. 1-B takes 1" or 1⅛" Manila rope in one end and ⅜" or ½" wire rope in other end. No. 3-B takes 1¼" or 1½" Manila rope in one end and ½" or ⅝" wire rope in other end.

TYPE C

Type C permits splicing on short Manila rope sections which are subject to most wear; for example, at cathead. No. 1-C takes 1" or 1⅛" Manila rope on both ends. No. 3-C takes 1¼" or 1½" Manila rope on both ends.

PETOL TOOLS TITAN TOOLS

GEARENCH MFG. CO.

HOUSTON, TEXAS, U. S. A.

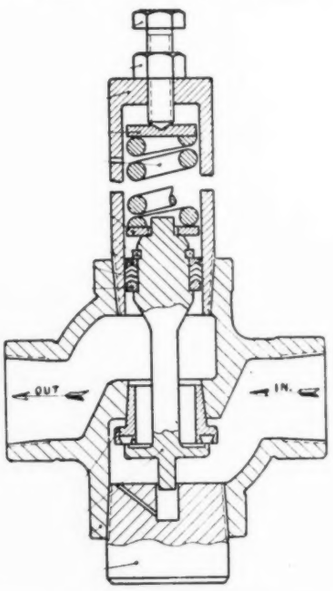
Export: 74 Trinity Place, New York City

PEI Well Purger

THE PEI Well Purger, after a testing and proving period of three years, is now being offered to the oil industry by Production Engineers, Inc., Houston, Texas, distributors of oil and gas specialties.

The PEI Well Purger is recommended, the manufacturer states, for use on wells that tend to die due to water or oil accumulating in the tubing, also on wells that the operator desires to flow on small chokes in controlling gas-oil ratio, when additional production at intervals is necessary to obtain allowable, or to prevent killing the well. The Purger is manufactured in two sizes: the low-pressure model is designed for opening pressures of 300 lb. or less, the high-pressure model for opening pressures greater than 300 lb. The terms "high pressure" and "low pressure" refer only to the size spring used, as each Purger is subjected to 3000-lb. test pressure.

The PEI Well Purger is a pressure-controlled valve and is installed in a bypass around the regular production choke on the Christmas tree, an additional choke being placed in the bypass, downstream from the Purger. When the tubing pressure drops to any point selected, due to the well loading-up with water or dead oil, the Purger valve opens, allowing the well to produce through its regular choke and the additional choke in the bypass. This increased rate of flow produces the accumulated water or dead oil from the tubing, which allows the tubing pressure to build back up. At the time the



tubing pressure has increased to approximately 10 percent above the pressure at which the Purger valve was set to open, the valve closes, restoring flow through the regular choke. A simple screw adjustment is provided whereby the opening pressure of the Purger valve can be adjusted at will by the operator.

The equipment is very compact, the low- and high-pressure models being only 20 and 26 in. high, respectively. Due to its simplified design, compact construction, and minimum number of parts, the unit has an extremely long life expectancy, the makers assert.

For further information, address Production Engineers, Inc., P. O. Box 2511, Houston, Texas.

Power Control Unit for Large Tractors

R. G. LeTOURNEAU, INC., introduces the R6-7-8 Power Control Unit. This two-drum unit is designed for interchangeability. The face plate is drilled to allow easy mounting on either D6, D7, or D8 "Caterpillar" tractors.

The same job-proved features that have made the Model R8 Power Control Unit so successful are incorporated in the R6-7-8, the manufacturer states. Its strong line pull of 5000 lb. enables it to handle the largest loads easily, it is asserted.

According to the makers, the R6-7-8 embodies these features: strong,

Investigate
GRIZZLY PERFORMANCE ON ANY WELL

25 Years of experience in the manufacture and use of brake lining for rotary drilling operations are back of the Grizzly Rotary Brake Blocks now in service. They are the finest and most efficient brake blocks we ever have produced, and they're doing an exceptionally fine job wherever they are used. Investigate their records of service on any well, in any field, if you want facts on superior braking performance and long trouble-free service. You can't go wrong on actual service records, and Grizzly performance is unsurpassed.

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Formerly E. M. Smith Co.
Plants: Los Angeles, California Paulding, Ohio
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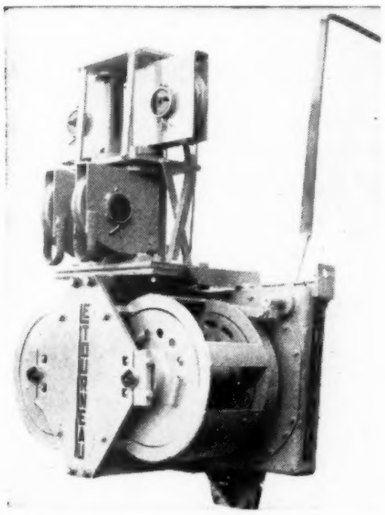
Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York, N. Y.
Distributed by Leading Supply Companies

GRIZZLY
Reg. U.S. Pat. Off.
ROTARY BLOCKS

rugged case; fewer moving parts; larger brakes and clutches; fast heat dissipation through larger exposed area



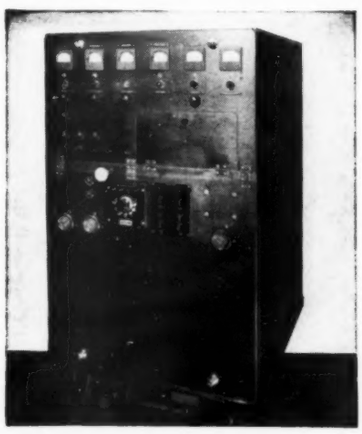
on brake drum; increased cable capacity; longer cable life because of larger drum area, and stronger line pull.

For complete information write to R. G. LeTourneau, Inc., Peoria, Illinois.

Mass Spectrometer for Gas Analysis

FOR industrial research, refineries, and chemical plants, a mass spectrometer is announced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

The unit is essentially a high-vacuum tube containing electrodes, filament, slit system, and an electron collector.



The gas or vapor to be studied is subjected to bombardment by a narrowly defined beam of electrons in the order of 10^{-6} amp. The pressure of gas in the ionization chamber where the bombardment takes place, is about 10^{-4} mm. of mercury or lower. The ions thus formed are accelerated through two narrow parallel slits in two parallel plates at a potential difference of from 100 to 1000 volts. The ions emerge from the second slit as a narrowly defined beam of very nearly the same energy. This beam is then deflected by a uniform magnetic field designed to sort the ions according to their mass-to-charge ratio. Thus the spectrometer gives directly information about the relative abundance of different kinds of molecular ion fragments formed when molecules of a particular kind are struck by electrons of known energy.

For quantitative indication of the gas to be measured, the ions strike a metal cup connected to ground through a very high resistance. The voltage developed across this resister is fed to the grid of an electrometer tube. This amplifies the current so it can be read with a sensitive galvanometer.

The spectrometer has been used successfully in studying patterns of organic molecules and in determining the purity of gas samples. Sensitivity in the case of air is one part in 100,000. Separation of mass 108 from mass 109 has been made.

Entire assembly is enclosed by steel panels having a black crackle finish except for the control panels, which are Micarta. Panels are hinged for accessibility to all parts. The unit is mounted on a rubber-tired truck for complete portability. Only outside connections required are 110 volts a.c. and water connections for cooling the pumps.

DRILL 5 WELLS
AT THE COST OF 4
Records of drilling rigs equipped with Twin Disc Torque Converters are showing an increased production of 20% to 25%. The economy of the Twin Disc Torque Converter is now fully demonstrated both in the added amount of "work done" it assures and the added protection it gives the equipment.
1. No time is lost shifting gears . . . the Torque Converter automatically adjusts the power to the load.
2. There is a smooth flow of power at all speeds . . . no pulsations . . . no "belt slap" . . . no "chain whip."
3. Jars and shocks are cushioned. This prolongs the wear-life of chains and cables.
4. Small, high-speed engines can be employed because of the automatic torque multiplication obtained with the Torque Converter.
5. The possibility of stalling the engine is eliminated.
6. You eliminate the wear and tear on gears, shafts and frictions.
TWIN DISC CLUTCH CO., 1329 Racine Street, Racine, Wisconsin.
Twin Disc Hydraulic Torque Converter. In considering installation, ask for complete data and specific recommendations.
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

Hunt Feed Water Compound

HUNT TOOL COMPANY, Houston, Texas, has announced the Hunt Feed Water Compound for use in oil fields where "bad water" is encountered. In addition to this special use, however, the manufacturer states that the compound is also an aid in keeping scale from forming, regardless of the kind of water used.

The Hunt Feed Water Compound is used directly in the feed-water pit in order to treat the water before it has entered the pumps or boilers. The compound dissolves slowly. By using this compound, most of the hardness of the water is settled-out in the pit, the manufacturer asserts.

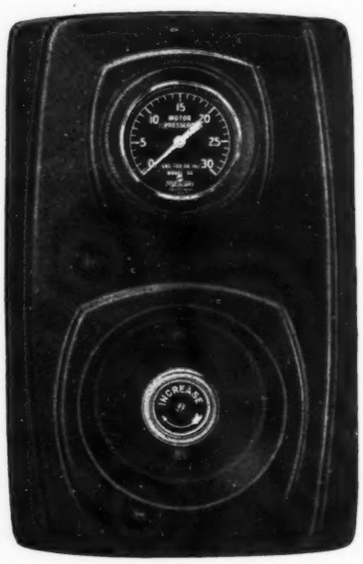
Hunt engineers state that only by inspecting the water can the proper amount of this feed-water compound be determined. When the compound is first used, it is stated that the operator should blow-down the boilers every two to three hours, according to the condition of the boiler. To obtain maximum efficiency, the boilers should be examined once a week to determine the increase or decrease in amount of compound to be used and the frequency of blow-down.

Write to Hunt Tool Company, Houston, Texas, for additional information.

Foxboro Remote Valve Control Unit

A NEWLY designed unit for the manual control of remote valves, dampers, and other pneumatically operated equipment is announced by The Foxboro Company. In appearance, the unit harmonizes with the rectangular case in which Foxboro recording and controlling instruments are now available. When the unit is flush-mounted, its front surface is only 7/16 in. from the surface of the instrument panel, and as its setting knob and pressure indicator are recessed, there are no protruding parts to suffer accidental bumps.

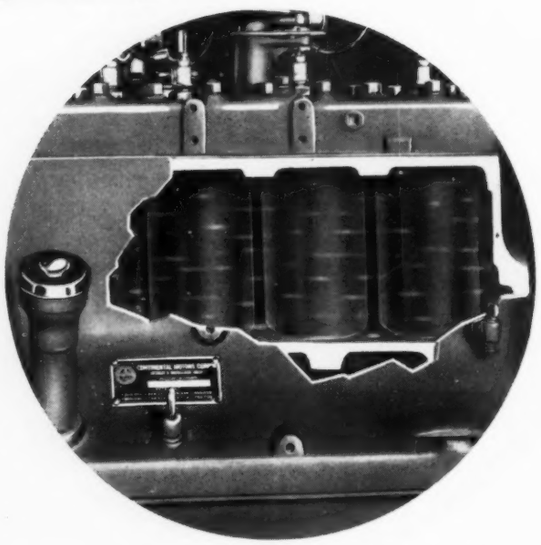
Specifically designed for dead-end service, the Remote Valve Control Unit will hold reduced pressures, dependably, to valves within very narrow



limits. Although most commonly used as its name suggests, it is equally useful in other applications, such as the setting of the control points of distant instruments or the adjustment of positioning or pressure-producing pistons, located in inaccessible points. It is practical for operation over distances as great as 1000 ft.

The unit is illustrated and fully described in Bulletin A-276 of The Foxboro Company, Foxboro, Massachusetts, of which copies will be sent on request.

Full Length Water Jacket!



The Continental full length water jacket with water completely surrounding each cylinder barrel, minimizes distortion. This permits closer fitting pistons resulting in less blow-by and lower oil consumption.

Other important features in Red Seal Continental Engines for oil field service are—directional cooling — packless, internally sealed, ball bearing water pump — interchangeable bearings — counterweighted crankshaft with precise balancing — pressure lubricated barrel-type tappets—and individual porting for quick starting, maximum power, economy and flexibility.

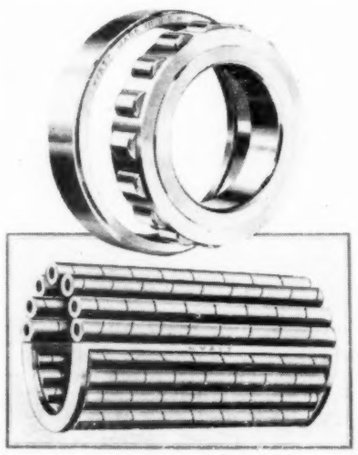
Sales and Service Facilities

Dallas: National Welding & Grinding Co.
Houston: C. Jim Stewart & Stevenson Co.
Longview: Standard Tool & Machine Co.
Wichita Falls: Wichtex Machinery Co.

Continental Motors Corporation
MUSKEGON, MICHIGAN

Anti-Friction Bearing 50 Years Ago and Today

How engineering, metallurgical, and manufacturing science over a half-century have met industry's anti-friction bearing demands for higher capacity in smaller space is pictured by the Hyatt Bearings Division, General



Motors Corporation, on their Fiftieth Anniversary. The first roller bearing built in 1892 by the inventor John Wesley Hyatt, with its helically wound rollers assembled loosely in a half cage, was a major contribution in its day. But what a contrast with a precision Hyatt Roller Bearing of 1942 as used in army and navy aircraft, with many times the capacity of its prototype and held to tolerances and uniformity of size undreamed of 50 years ago.

West Virginia Meter School Postpones Meeting

A meeting of the general committee of the Appalachian Gas Measurement Short Course was held at West Virginia University on February 17, 1942, presided over by Chairman J. E. Overbeck of the Columbia Engineering Corporation, Columbus, Ohio.

On motion, the committee voted as follows:

"(1) That the committee defer action on the selection of a date for a school for this year, pending future developments which may or may not make a school in 1942 feasible.

"(2) That a future committee meeting may be held at the call of the chairman in the event that developments warrant such a meeting or indicate the opportunity or necessity of a school during the year 1942.

"(3) That the general committee organization be held intact until after the next school is conducted and that operating committees for the next school be appointed."

Haering Publishes Text on Cooling Water

A comprehensive text on scale, corrosion, and living organisms in cooling system operation is a new 46-page Haering booklet of reprints of significant published articles on this subject.

Recognizing the need for a concise discussion of all phases of this currently vital industrial subject, D. W. Haering and Company, Inc., have reprinted a series of articles from *Refiner and Natural Gasoline Manufacturer* and from *Industrial and Engineering Chemistry* for general distribution.

Subjects covered in this new Haering contribution to scientific water literature include experimental methods of studying cooling system problems, discussion of the causes and prevention of corrosion both of steel and copper alloys, and microbiological deposits. The booklet is profusely illustrated with charts, tables, and half-tones.

Copies of this booklet, which should be of interest to everyone interested in water or cooling system design and operation, may be obtained without cost or obligation by addressing requests on business letterheads to D. W. Haering and Company, Inc., 205 West Wacker Drive, Chicago, Illinois.

COLMONOY

2400 Work Hours—Against 360

On large oil company tells us that COLMONOY coated pump sleeves run 2400 hours, pumping hot oil at 900°, with pump running at 3600 R.P.M. Other sleeves tested ran only 360 hours.

COLMONOY is playing an important part in oil production and refining operations in the United States. Pump sleeves, plungers, rings, wash pipes and many other kinds of equipment used in the oil industry are particularly subject to excessive corrosion and abrasion.

COLMONOY Keeps Them on the Job.

Worn out parts, COLMONOY coated, will outwear and outperform new, unsurfaced parts many times over.

Investigate COLMONOY Today

Catalog mailed on request.

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208 Midco Building TULSA
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21 Seneca St. BLASDELL, N. Y.
123 W. Philadelphia St. WHITTIER, CALIF.

COLMONOY

Hard Surfacing Alloys and Overlay Metals

Two Bullard Offices in Larger Quarters

E. D. Bullard Company, safety equipment manufacturers, announces its Los Angeles, California, and Denver, Colorado, offices have moved to larger quarters. The Los Angeles office, managed by Alton A. Castle, is now at 1213 South Olive Street. The telephone number is the same as formerly, PRospect 2345. In Denver, the office is at 56 Wazee Market. Tom Hallinan is in charge. The telephone number is unchanged, KEystone 0443.

A.P.I. 1942 Mid-Year Meeting Cancelled

The Twelfth Mid-Year Meeting of the American Petroleum Institute, scheduled for May 25, 26, 27, and 28 at Oklahoma City, Oklahoma, will not be held, W. R. Boyd, Jr., A.P.I. president, has announced.

Extreme demands of the war upon the vital petroleum industry, which is supplying explosives, synthetic rubber, glycerine, ethyl alcohol, and many other synthetic raw materials made from crude oil, as well as unprecedented quantities of its normal products, and the solution of an ever-increasing transportation problem, are keeping members of the Institute and of its working committees so actively engaged that the Institute's executive committee, upon recommendation of President Boyd, decided to cancel the meeting.

"Bill" Champion New Arrival

Mr. and Mrs. Frank Champion announce the birth at Los Angeles, California, on February 18, 1942, of William Lamb Champion.

Champion is vice-president and general sales manager of the Oil Tool Division of Byron Jackson Company.

Los Angeles Inducts Officers

A meeting of particular interest and importance was held in Los Angeles by the Los Angeles Chapter of Nomads, Wednesday evening, March 11. Immediately after dinner the new chapter officers and regents were inducted; several South American consuls were then introduced, and the meeting closed with a talk on the petroleum situation in the Near East.

The induction ceremonies for the new officers were handled by Ernie Fowks, the retiring president, who introduced the officers with a brief outline of their Nomad activities. They were presented in the following order: Roland Smith, sergeant-at-arms, and Tom Murphy, assistant sergeant-at-arms; Elmer Smith and D. B. Waite, treasurer and assistant treasurer; Bob Eiche and Jack Ballagh, secretary and assistant secretary; Earl Rees, vice-president, and Bill Bettis, president. Joe Swaton then served as induction master for the national regents and presented Ted Sutter and Ernie Fowks, who are the new regents for the Los Angeles Chapter.

Bart Gillespie, aided by his fluent Spanish, presented the consular guests. They were Hon. Manuel E. Hubner, consul general for California from Chile; Hon. A. Posse Rivas, consul for California from Venezuela; Hon. Juan M. Gutierrez, vice-consul for California from Argentina, and Hon. Teodoro Gallac, secretary for the Argentina Embassy in Ecuador. Sr. Hubner then gave a short talk that was appreciated by those present.

The guest speaker, William T. Foran, entitled his talk "The Axis Squeaks for Oil." According to Foran, who spent five years on geological work for the Iraq Petroleum Company and allied interests in the Near East, Hitler is not only squeaking for oil but is squawking for it. He believes that Germany's

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1 **Union-Formed** (pre-formed) ropes resist unraveling and unlaying when cut.

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3 They are installed more easily and quickly.

4 They spool evenly and tightly, due to their freedom from crankiness.

5 **Union-Formed** wire ropes resist kinking, as the structure is inert.

6 They resist drum-crushing better, because of even spooling and firm body.

7 They end "porcupining." The wires when worn lay flat to the rope.

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reserves are about gone and that with his present supply of oil limited to what he can get from Roumania, Poland, Albania, Germany, and by synthetic means Hitler is not going to be able to put on another high-powered blitz. Regarding Japan, he believes the Japs have about a two-year supply of oil without augmenting it from the Indies.

·Guests from foreign countries included Meade McCamey of N.K.P.M., Palembang, Sumatra; D. T. Sullivan of Colpet from Colombia; Fred E. Vandenburg of Colpet from Colombia; R. H. McLelland of United British Oilfields of Trinidad from Point Fortin, Trinidad; C. A. Ricks of C.P.C. from Venezuela; A. F. Driskill of Iraq Petroleum Company from Kirkuk, Iraq; Frank McAteer from Canada, and J. F. Foran of Cia Aurifera Nasca, Lima, Peru.

E. J. Weis Vice-President Pacific Pump Works

According to an announcement by J. B. O'Connor, chairman of the board of Pacific Pump Works, Elmer J. Weis, former aircraft parts manager, has

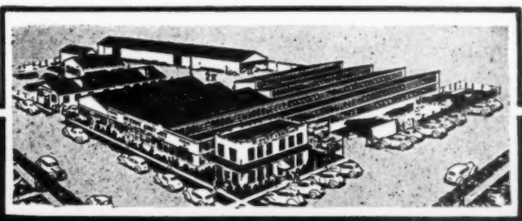
ELMER J. WEIS

been elevated to the vice-presidency of the company.

Because of the need for top-ranking engineers at this time, according to O'Connor, Weis will retain an active interest in the company's engineering developments, in addition to handling his new responsibilities.

Weis originated, and up to the present time has been responsible for, the operation and supervision of the company's aviation hydraulic actuating assembles division. He has performed a noteworthy and timely job of supplying the aviation industry with vital hydraulic assemblies. For the last several years, however, he has also been identified with many engineering improvements in Pacific Pump Works' complete line of centrifugal pumps for municipal, industrial, refinery, pipeline, and hot oil services; deep-well centrifugal turbines and deep-well oil pumps.

Vice-President Weis has been with Pacific Pump Works since its organization in 1923.



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ARMSTRONG BROS. Knife Blade Cutter Wheels cut much faster and easier, hold their keen cutting edge, for they are made of Vanadium Tool Steel, heat treated and hardened.

Write today for Catalog C-39, showing the most complete line of Pipe Tools made.

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"The Tool Holder People"
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Sand-Banum is the tried and proved method of eliminating and preventing boiler scale and corrosion — regardless of condition of your boiler feed water.

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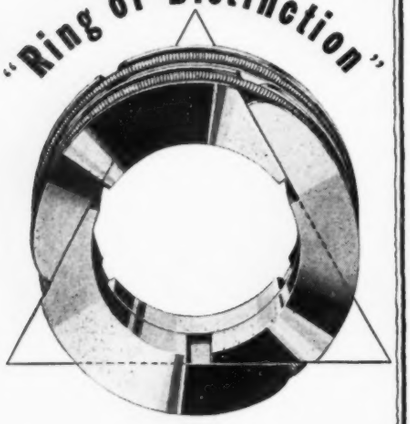

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"France Metal Packing used on our engines for 27 years and is still working under a pressure of 170 lbs. superheated. ..... will in all probability outlive us."

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Original FRANCE METAL PACKING

Axelson Celebrates Golden Anniversary

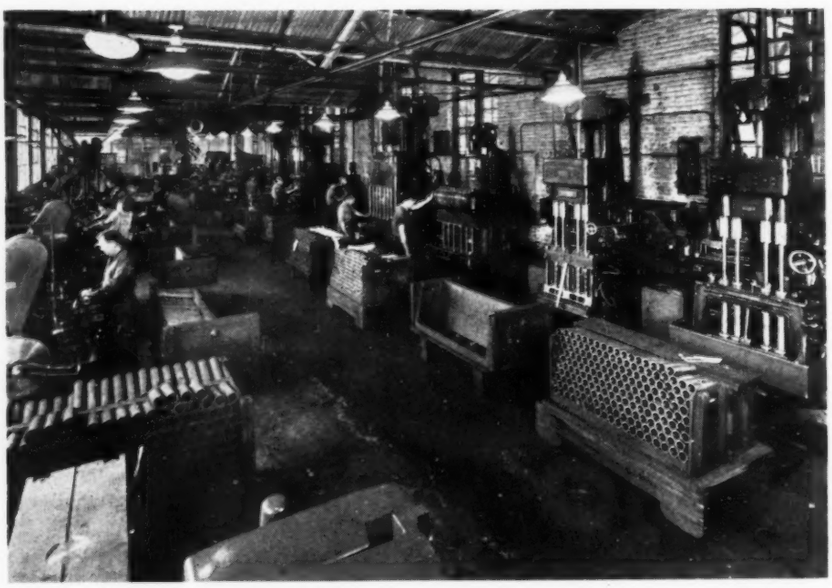
Fifty years of service to the petroleum industry! Years that have seen greater and greater demands heaped on the oil-well suppliers. A half century during which technological improvement has made possible the tapping of new oil sources, the operating of wells more efficiently, and the keeping abreast of skyrocketing oil demand.

J. C. Axelson, President and General Manager

That's the story behind the announcement made by J. C. Axelson, president and general manager of the Axelson Manufacturing Company, that the company is this year celebrating its golden anniversary.

As pioneers of a number of design

On the left, C. F. Axelson and, on the right, G. A. Axelson, the original founders of the Axelson Manufacturing Company



View of Axelson pump liner department

Plant view of machining and threading operations of sucker rod pin ends

improvements in pumps, sucker rods, and other requisites of the petroleum industry, Axelson posseses a most interesting history. In 1892, on an original capital investment of $1200 scrimped from wages, a small iron works in the then country town of Santa Ana, California, was purchased by two Axelson brothers, C. F., a machinist, and G. A., a molder. Even to these young middle westerners, whose later accomplishments proved their vision, this could hardly have seemed the beginning of a firm that today enjoys a $6,000,000 annual sales volume. Behind the story of Axelson's successful operation lies an idea possessed by the Axelson brothers, C. F. and G. A., from the time they were ten years of age. Both had made up their minds that they were going to have a manufacturing plant, complete with machine shop and foundry and their every move from that point on was made towards this predetermined objective.

Today the sons of these founders, carrying along the research methods and production standards that originally distinguished the Axelsons, are operating a company whose scope of oil-field service is literally described in their paraphrased slogan: "The sun never sets on Axelson pumps and sucker rods." And in 1942 the Axelson foundries, machine shops, and assembly lines are supplying American war industry—for the second time—with essential production and maintenance equipment. Developed during the first World War, Axelson's well-established line of machine tools, heavy-duty lathes and accessories are under "All-Out" production to supply America's 1942 Victory Program. Pumps, sucker rods, gauges, and numerous other oil-field supplies are essential to our "Keep 'em Pumping" oil program.

Simultaneously, the company this year will produce a large volume of aviation parts for Allied warplanes, according to vice-president (and also "second generation"), D. F. Axelson.

J. L. Joplin New Sales Manager Buda

J. L. Joplin has been appointed sales manager of Buda Engine and Equipment Company, and will make his headquarters in Houston, Texas.

J. T. McFarland is being transferred from Odessa, Texas, to Wichita Falls, and will be in charge of North and West Texas.

Frank Dalling, formerly at Wichita Falls, is being transferred to Houston.

J. M. Bridges, formerly in Corpus Christi, is being transferred to Odessa, Texas.

Dual Completion
WITH THE
OTIS TYPE G (Side Door) CHOKE

Provides A Means To...

1. "Bring-In" Annulus after well has been hooked-up and tied down.
2. Take Bottom Hole Pressures of each formation.
3. "Kickoff" the Annulus should it become loaded-up.

NOTE: All these operations are performed without moving tubing or breaking packer seal.

THE OTIS TYPE G CHOKE greatly simplifies the completing and producing of two-zone wells. Through its use, both the upper and lower zones can be either swabbed-in or circulated-in after the tubing connections have been permanently hooked-up and tied down.

Bottom hole pressures can be taken of each zone independently of the other. This tool also makes possible the "kickingoff" of the annular space should it become loaded up, without moving the tubing. These operations are made possible because the Type G Choke provides a means to control the entrance of fluid into the tubing string from either or both pays.

By equipping the choke with a blank cup mandrel which has an open bore, the upper formation is blanked off and the tubing made a conductor from the lower zone only. Conversely, if a perforated cup mandrel is used with its lower end plugged, the lower formation is blanked off and the tubing made a conductor for the upper formation only.

Write or call your nearest Otis representative for details

OTIS PRESSURE CONTROL, INC.
DALLAS, TEXAS

Branches: Houston, Texas; Hobbs, New Mexico; New Iberia, Louisiana

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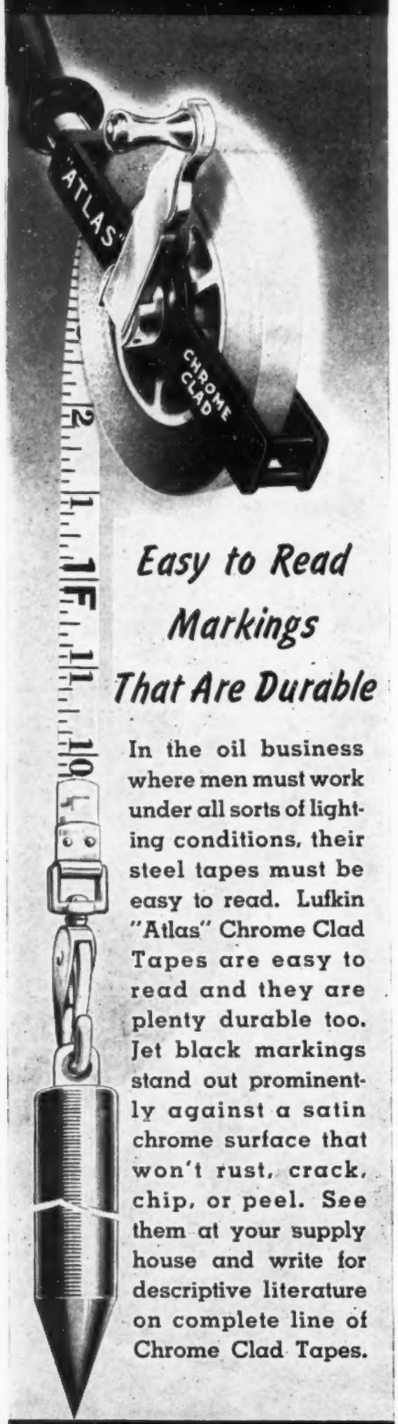
"ATLAS"
CHROME CLAD
STEEL TAPES



Easy to Read Markings That Are Durable

In the oil business where men must work under all sorts of lighting conditions, their steel tapes must be easy to read. Lufkin "Atlas" Chrome Clad Tapes are easy to read and they are plenty durable too. Jet black markings stand out prominently against a satin chrome surface that won't rust, crack, chip, or peel. See them at your supply house and write for descriptive literature on complete line of Chrome Clad Tapes.

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E. H. Brown Made Vice-President Allis-Chalmers

Edwin H. Brown has been elected a vice-president of the Allis-Chalmers Manufacturing Company, in charge of engineering and development, it is announced by W. C. Buchanan, president.

Before assuming the new post, in which he will correlate all engineering activities and the development of new products, Brown was manager and chief engineer of the engine and condenser department for seven years.

The administration of the engine and condenser department has been taken over by M. L. Carson, sales engineer.

Dave Buttles Promoted By Cummins Engine

P. E. Letsinger, vice-president in charge of sales, Cummins Engine Company, announces the appointment of D. J. Buttles as western manager with offices in the newly-established, direct factory branch at Salt Lake City, Utah.

The 11 western states have always been one of the most important markets for Cummins Diesel engines. In addition to the Pacific Coast states, the territory includes British Columbia, Alaska, and Hawaii.

D. J. BUTTLES

Under Buttles' management are three sales regions. In each of these is a sales representative. R. H. Wills is in charge of the Northwest Region; Tom Collins, the Southwest Region, and it is understood that a new man will be selected to cover the third region. The new man to be selected will make his office either at the branch in Salt Lake City, or the sub-branch in Denver. No announcement has yet been made of the local manager for Salt Lake City or Denver.

Service in this territory will be handled by two of the best known and most competent men in Cummins' organization — Paul Phillips will work out of the Salt Lake branch covering the Northwest and Clyde Tatman, who for the last nine years has been associated with the Diesel Motor Sales and Service Company of Los Angeles, will cover the Southwest.

With the Cummins factory now on a 24-hour, 7-day-a-week schedule, engine production has been stepped-up nearly three times. This entire engine volume is going directly to prime defense uses. The increased tempo of these times forbids any long distance contacts and the Cummins Engine Company feel that Buttles and the Salt Lake City branch will prove a big help in maintaining a closer factory-owner understanding.

One of the important projects before the factory branch is the study of unit repair, that is, the exchange of complete units for service. In coöperation with Cummins dealers and owners, this study will be carried on continuously to assure a progressively better service policy.

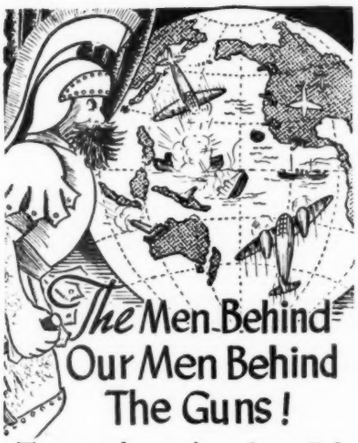
Plans Dual-Completion Wells

O. L. Gragg, Palestine, Texas, oil operator, has been interested in the drilling and production of oil since 1934, and at the present time has extensive production in Long Lake and Cayuga fields. Gragg has announced that he plans future drilling in these areas, with a number of the wells to be dual completions due to their economy of equipment and certain operating advantages.

O. L. GRAGG

Meter Company Employees Invest in Defense Bonds

The Pittsburgh Equitable Meter Company and subsidiaries, of Pittsburgh, Pennsylvania, have made available a pay-roll allotment plan whereby accumulated savings from the earnings of employees will be used to purchase United States Defense Bonds in the workers' names.



The great drama of war has rolled back its curtain extending around the world. "Our Men Behind the Guns" have successfully met the enemy at some points and are preparing to meet them anywhere. "The Men Behind Our Men Behind the Guns" are the scene shifters on this huge stage of the "Theatre of War."

Because the grim show must go on, hotel men have a patriotic duty to perform... that of keeping these myriads of men of industry comfortable while away from their homes. "Keep 'em fit on the home front to keep 'em fightin' on the war front" —for health and comfort, good food and good rest are important. Let's bend every effort to keep these direct forces of energy at the "Peak of Perfection."

ALABAMA
Hotel Admiral Semmes.....Mobile
Hotel Thomas Jefferson.....Birmingham

DISTRICT OF COLUMBIA
Hotel Washington.....Washington

ILLINOIS
Hotel Faust.....Rockford

LOUISIANA
Jung Hotel.....New Orleans
Hotel DeSoto.....New Orleans

MISSISSIPPI
Hotel Lamar.....Meridian

NEBRASKA
Hotel Paxton.....Omaha

NEW MEXICO
Hotel Clovis.....Clovis

OKLAHOMA
Oklahoma Biltmore.....Oklahoma City
Hotel Aldridge.....Wewoka

SOUTH CAROLINA
Hotel Wade Hampton.....Columbia

TEXAS
Hotel Alice.....Alice
Hotel Stephen F. Austin.....Austin
Hotel Settles.....Big Spring
Hotel Brownwood.....Brownwood
Hotel Southern.....Brownwood
Hotel Laguna.....Cisco
Hotel Cortez.....El Paso
Hotel Texas.....Fort Worth
Hotel Buccaneer.....Galveston
Hotel Galvez.....Galveston
Hotel Jean LaFitte.....Galveston
Coronado Courts.....Galveston
Jack Tar Court.....Galveston
Miramar Court.....Galveston
Hotel Cavalier.....Galveston
Hotel Plaza.....Laredo
Hotel Lubbock.....Lubbock
Hotel Falls.....Marlin
Hotel Cactus.....San Angelo
Angeles Courts.....San Antonio

VIRGINIA
Mountain Lake Hotel.....Mountain Lake

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SERVING 10 STATES AND OUR NATION'S CAPITAL

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Industrial Engineering Announces Administrative Changes

Announcement is made of a change in the administrative organization of Industrial Engineering Company, manufacturers of Somastic pipe coating. H. C. Price, Bartlesville, Oklahoma, is president; W. W. Colley, Houston, Texas, vice-president and general manager, and K. H. Dyer, Wilmington, California, Pacific Coast manager. Other officers are S. D. Bechtel, San Francisco, California, chairman of the board; K. K. Bechtel, San Francisco, vice-president and treasurer, and W. E. Waste, Los Angeles, California, secretary. Directors are Henry J. Kaiser and G. G. Sherwood, both of Oakland, California, in addition to the principal officers.

Offices are maintained at Houston, Wilmington, Bartlesville, and San Francisco. Central plants are operated at Houston and Wilmington.

Harold C. Price, the new president, is the head of the well-known pipeline welding organization of H. C. Price Company. W. W. Colley has been associated with the Industrial Engineering Company for many years, both in California and Texas. K. H. Dyer was associated with Industrial Engineering Company in its early days. S. D. Bechtel and K. K. Bechtel are executives of W. A. Bechtel Company, engineers and contractors. W. E. Waste is administrative manager of the California Shipbuilding Corporation, Wilmington, California. H. J. Kaiser and G. G. Sherwood are of the Henry J. Kaiser Company, Oakland.

Pomona Pump Acquires Westco

Pomona Pump Company, manufacturers of vertical pumps, announces the purchase of the Westco Pump Division of Micro-Westco, Inc., Bettendorf, Iowa.

The newly acquired business will be operated as Pomona Pump Company, Westco Division, at 2621 Locust Street, St. Louis, Missouri, and manufacture continued from the St. Louis plant of the Pomona Pump Company. Management and key personnel of Westco will be transferred to St. Louis to continue the manufacture and distribution of the complete line of Westco pumps through the same national organization that has been carefully built-up by Westco over the last 16 years.

Heads Legal Staff

Samuel H. Riggs now heads the legal staff of the Cities Service Oil Company in Chicago, Illinois., succeeding Warren Spies.

CHIKSAN
Ball Bearing Swing Joints can help you with your flexible line problems.

Problem #1
How can I make present flexible lines last longer?

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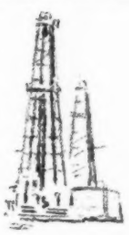
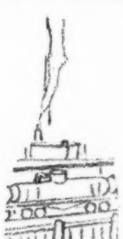


CHIKSAN All-Steel Rotary Hose and Circulating Heads—CHIKSAN High Pressure Swing Joints for end connections for rubber rotary hose—CHIKSAN High Temperature Joints for steam lines.

FOR REFINING:

Over 500 different types, styles and sizes for high and low pressures and for temperatures to 700°F. Sizes from ⅜" to 12". Larger sizes to order. CHIKSAN Swing Joints used as end connections lengthen the life of all flexible lines.

FOR MARKETING:



CHIKSAN All-Steel Barge and Dock Hose for loading and unloading—CHIKSAN Swing Joints for end connections make rubber hose lines last longer. Full 360° rotation in 1, 2 and 3 planes. CHIKSAN Swing Joints are used as standard equipment on thousands of Loading Racks.

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CHIKSAN
BALL BEARING SWING JOINTS for ALL PURPOSES
BREA, CALIFORNIA
ALL-STEEL ROTARY HOSE
CIRCULATING HEADS · MUD GUNS
THREE-WAY DISC BIT
STANDARD and HEAVY DUTY REAMERS

"I'm Still Working..Thanks to My Hard Boiled Hat"

Says an oil company worker: "A three man rivet buster was on one side of the tank, and I was on the other with a broom. The rivet head sheared off, glanced from the frame and hit my 'hard boiled' hat."

SAVE MONEY on protective hats with Bullard's simplified stock control system. Ask for new folder: *"How to Select Head Protection at a Saving."*

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All back copies of THE PETROLEUM ENGINEER comprising Volumes 3, 4, 5, 6, 9, 10, 11, and 12. The copies to be purchased for donation to a state university library. Please state price required. Address reply to THE PETROLEUM ENGINEER, Box 1598, Dallas, Texas.

A.P.I. Eastern District Preliminary Program

The American Petroleum Institute Eastern District Division of Production has announced the preliminary program for its spring meeting to be held at the William Penn Hotel, Pittsburg, Pennsylvania, April 9 and 10. The program follows:

Thursday, April 9

8:00 a. m.—Breakfast meeting for officers of the Eastern District, presiding officers, authors and discussers, Forum Room, 17th Floor, William Penn Hotel.

8:30 a. m.—Registration headquarters on 17th Floor William Penn Hotel. A registration fee of $1.50 will be charged each registrant to cover incidental costs of meeting and copies of papers. Registration fee, including ticket for annual dinner, will be $5.00. Separate tickets may be purchased for the dinner at $3.50. All members desiring to attend the dinner should purchase their tickets before Thursday noon; in order to avoid misunderstanding and duplication, reservations will be made only when tickets are paid for in advance.

Place of Meetings

All technical sessions will be held in the Urban Room, 17th Floor of William Penn Hotel, unless otherwise indicated. The Annual Dinner will be held in the ballroom on the same floor.

Morning Session

10:00 a. m.—Presiding: O. W. Van Petten, The Columbian Carbon Company, Charleston, West Virginia.

Address of Welcome: Honorable Cornelius D. Scully, Mayor, City of Pittsburgh.

Response: O. W. Van Petten, Chairman, Eastern District, A.P.I. Division of Production.

"Rotary Drilling in the Appalachian Fields," by E. H. Tollefson, Hope Natural Gas Company, Clarksburg, West Virginia.

"Deep Rotary Drilling in Michigan," by G. C. MacDonald, Gulf Oil Corporation, Tulsa, Oklahoma.

Panel discussion of papers—Leaders: R. J. Sullivan, The Carter Oil Company, Mattoon, Illinois; John R. Thompson, Belmont Quadrangle Drilling Company, Bradford, Pennsylvania; Bart DeLaat, The Pure Oil Company, Chicago, Illinois; F. J. White, E. H. Fitler Rope Company, Bradford, Pennsylvania.

Afternoon Session

2:00 p. m.—Presiding: DeWitt T. Ring, Preston Oil Company, Columbus, Ohio.

"The Responsibility of the Oil Industry in the War," by D. R. Knowlton, Director of Production, Office of Petroleum Coördinator, Washington, D. C.

Address: Walter S. Hallanan, Plymouth Oil Company, Charleston, West Virginia, Chairman Oil Production Committee for District No. 1.

Address (tentative): J. French Robinson, East Ohio Gas Company, Cleveland, Ohio, chairman, Natural Gas and Natural Gasoline Committee for District No. 1.

Address: Frank M. Brewster, Director of Natural Gas for District No. 1, Office of Petroleum Coördinator, Washington, D. C.

Thursday Evening

Victory Dinner—7:00 p. m.
Presiding: O. W. Van Petten.
Toastmaster: (To be announced).
Address: Honorable Wesley E. Disney, Member of Congress from Oklahoma, Washington, D. C.

Friday, April 10

8:00 a. m.—Breakfast meeting for presiding officers, authors and discussers, Forum Room, 17th Floor, William Penn Hotel.

Morning Session

10:00 a. m.—Presiding: F. E. Eckert, Hanley and Bird, Bradford, Pennsylvania.

"Individual Well Electric Jacks," by H. O. Murphy, Lloyd Smith Company, Bradford, Pennsylvania.

Panel discussion — Leaders: Wilson K. Page, Olean Petroleum Company, Olean, New York; Max Sherwood, Shell Oil Company, Inc., Centralia, Illinois; W. B. Stamford The National Supply Company, Pittsburgh, Pennsylvania.

"Heat Exchangers and Cooling Towers and Their Application to Compressor Plan Installations," by W. E. Dunn, The Fluor Corporation, Kansas City, Missouri; Hugh R. Lamberth, The Fluor Corporation, Los Angeles, California.

Panel discussion—Leaders: John W. Partridge, United Fuel Gas Company, Charleston, West Virginia; A. C. Perry, Peoples Natural Gas Company, Pittsburgh, Pennsylvania; John A. Clark, Hope Natural Gas Company, Clarksburg, West Virginia.

"Recent Advances in the Selective Shooting of Producing Horizons," by Harry M. Ryder, Ryder Scott Company, Bradford, Pennsylvania.

Panel discussion — Leaders: C. J. Haas, Adams Oil and Gas Company, Centralia, Illinois; A. J. Saxe, South Penn Oil Company, Bradford, Pennsylvania; H. H. Wright, Gulf Refining Company, Indianapolis, Indiana; R. S. Pringle, Jr., Pringle Powder Company, Bradford, Pennsylvania.

Afternoon Session

2:00 p. m.—Presiding: J. J. Schmidt, East Ohio Gas Company, Cleveland, Ohio.

Report of Nominating Committee.

Election of district officers and Advisory Committee.

Reports on Eastern District Chapters: Michigan Chapter: C. C. Irby, chairman; Illinois Basin Chapter: C. J. Haas, chairman.

"Geologic Distribution of Oil in the Illinois Basin," by B. F. Hake, Gulf Refining Company, Indianapolis, Indiana.

Panel discussion—Leaders: L. M. Clark, Shell Oil Company, Inc., Centralia, Illinois (tentative); George Wesley, Skelly Oil Company, Evansville, Indiana.

"Flow of Natural Gas in Pipelines," by E. N. Kemler and N. Kulik, School of Mechanical Engineering, Purdue University, Lafayette, Indiana.

Panel discussion—Leaders: C. F. DeMey, Ohio Fuel Gas Company, Columbus, Ohio; T. R. Weymouth, Advisor to the Office of Petroleum Coördinator, Greenwich, Connecticut; R. J. S. Pigott, Gulf Research and Development Company, Pittsburgh, Pennsylvania.

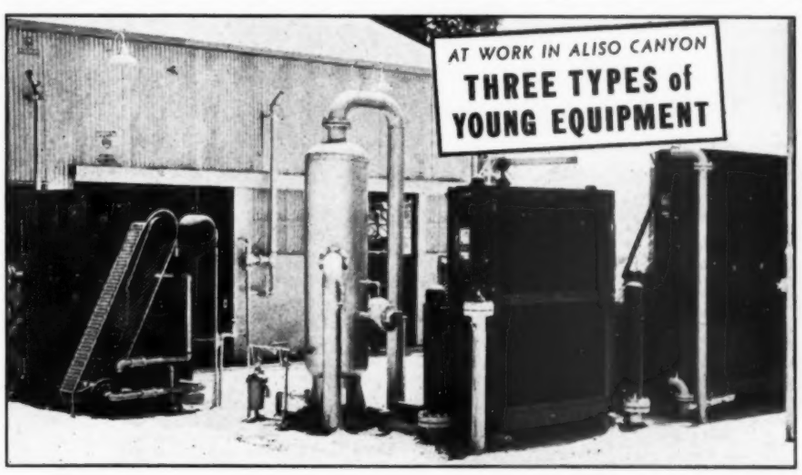
"Use of Gel-Type Cement in Cementing Casing," by J. T. Reynolds, Halliburton Oil Well Cementing Company, Chicago, Illinois.

Panel discussion—Leaders: M. R. Joy, Cities Service Oil Company, Carmi, Illinois (tentative); R. B. Anderson, Columbian Carbon Company, Charleston, West Virginia (tentative); Amos Roberts, Baroid Sales Division, National Lead Company, Olney, Illinois.

B. P. Sibole Heads Stanolind Pipe Line Company

B. P. Sibole, formerly vice-president, has been made president of the Stanolind Pipe Line Company. A. W. Peake, who has been president, becomes chairman of the board of directors, thus returning to the position he held prior to the retirement in November, 1940, of R. S. Ellison as president. As vice-president, Sibole has been in active charge of company operations, and states "there is no special reason for recognizing the removal of 'vice' from my title. Our organization and duties remain practically as before. Mr. Ellison was president of Stanolind Pipe Line Company and Stanolind Oil Purchasing Company. No one has attempted to fill his place. In November, 1940, Mr. R. O. Dietler replaced him as president of the Stanolind Oil Purchasing Company, which is a real job in buying the oil we deliver."

Simple Vortox Design Gives
Maintenance-free
AIR CLEANING EFFICIENCY
With the simple Vortox Air Cleaner design, there are no felt or cloth filters to clean or replace. Instead, the all-metal filter element is kept continuously clean by the washing action of oil . . . not only eliminating constant attention, but maintaining full air flow as well. A periodic oil change is the only maintenance required!
Here's the Vortox triple cleaning action that gives maximum efficiency over long periods: Centrifugal action first rapidly whirls the incoming air and centrifugates most of the dust out of the vortex chamber and into the oil reservoir.
Cyclonic oil spray, set up by the whirling air, drenches the wire filter element and at the same time scrubs the air for removal of the finer dust particles.
Oil washed filter element gives the air a final cleaning and removes all oil from the air, delivering it dry and dust-free to the engine.
That's why Vortox-equipped engines and compressors stay trouble-free and efficient longer, even under the most severe dust conditions. Make sure your engines have this extra measure of protection!
VORTOX MANUFACTURING CO. • CLAREMONT, CALIFORNIA
VORTOX
OIL TYPE SELF-WASHING
AIR CLEANER



That YOUNG equipment will handle a wide range of oil field requirements and do it at a substantial saving is well illustrated by this unusual installation. Three different types of YOUNG heat transfer units serve a 300 H.P., 2 stage natural gas compressor with a 2,000,000 cu. ft. twenty-four hour capacity. The YOUNG FULL-FLOW Engine Jacket Water Cooler (extreme right) cools engine and compressor jacket water. The YOUNG Gas Cooler (center) consists of two coil sections to cool the gas through both stages of compression. A YOUNG Evaporative Cooler (left) cools the gas from an atmospheric to a wet bulb temperature. Write for catalogs and engineering data.

YOUNG RADIATOR COMPANY — Dept. 282-C, Racine, Wis., U.S.A.
Mid-Continent Distributor — THE HAPPY CO., Tulsa, Okla.
Pacific Coast Distributor — A. R. FLOURNOY, Bell, Calif.

Young HEAT TRANSFER PRODUCTS
OIL COOLERS • GAS, GASOLINE, DIESEL ENGINE COOLING RADIATORS • INTERCOOLERS • HEAT EXCHANGERS • ENGINE JACKET WATER COOLERS • UNIT HEATERS • CONVECTORS • CONDENSORS • EVAPORATORS • AIR CONDITIONING UNITS • HEATING COILS • COOLING COILS
Young SERVICE

J. H. Williams & Co. Elect New Officers

At a meeting held in New York City, February 26, the board of directors of J. H. Williams and Company, manufacturers of drop-forgings and drop-forged tools, elected new officers and filled the vacancy caused by the recent death of J. Harvey Williams, president.

E. J. WILCOX

The new officers are as follows: A. Donnally Armitage, president; E. J. Wilcox, vice-president in charge of stock products sales; Willard C. Kress, vice-president in charge of all manufacturing; Hugh Aikman, secretary; and Clark M. Fleming, treasurer.

Armitage, former vice-president of the company, will continue to make his headquarters at Buffalo, whereas Wilcox, formerly sales manager of the Stock Products Division, will continue at the company's general sales office, 225 Lafayette Street, New York City. All officers have long been associated with the firm—Kress as works manager, and Fleming and Aikman occupying the offices to which they were re-elected. Fleming, in addition to being treasurer, was elected a director to fill the vacancy caused by Williams' death.

J. Harvey Williams died in a New York City hospital, February 23. Death was due to heart failure resulting from the shock of an operation performed a few weeks previously. He would have been 60 years old March 22.

Williams was born in Brooklyn, New York, in 1882, the elder son of James H. Williams, founder of J. H. Williams and Company, and Harriet Trumbull Williams. After the death of his father in 1904 he became vice-president of the company, then in 1916, president.

Made Vice-Presidents Of General Electric

T. F. Barton of New York City and W. B. Clayton of Dallas, Texas, have been elected commercial vice-presidents of the General Electric Company, it is announced by President Charles E. Wilson. Both have been district managers in their respective territories and will continue as such.

Barton, a native of Orangeburg, S. C., entered the employ of General Electric in 1906, the year he graduated from Clemson A. and M. College. He became district engineer of the New York territory in 1927, was appointed assistant manager of the district in 1939, and manager on January 1, 1941. He has twice won the Charles A. Coffin Foundation award, highest

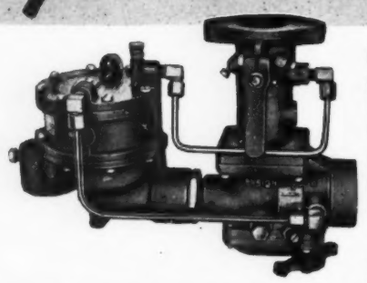
T. F. BARTON

W. B. CLAYTON

honor that General Electric bestows upon its employees.

Clayton, a native of Brooklyn, New York, graduated from the Alabama Polytechnic Institute in 1905 at the age of 17 and joined General Electric that year as a student engineer. In 1924, when the Southwest District was organized with Dallas as headquarters, Clayton was named manager of the Central Station Department and assistant manager of the district. In November, 1939, he was elevated to the post of district manager.

Good Carburetion —AN ESSENTIAL



Speaking of essentials—good carburetion is vitally necessary for continuous dependable engine performance. Building good carburetion equipment is our business.

Essentially, internal combustion engines provide the most valuable source of power—the kind of power that will win a mechanized war. Drilling wells, pumping the crude, refining and transporting the finished product—high test gasoline utilized in a thousand defense needs.

Maximum engine performance depends upon the accurate control and proportioning of gas-air mixtures. This is the principal function of ENSIGN Fuel Regulators and Gas Carburetors.

Constant research and testing results in the development and application of new and improved principles—those features you enjoy in today's carburetion.

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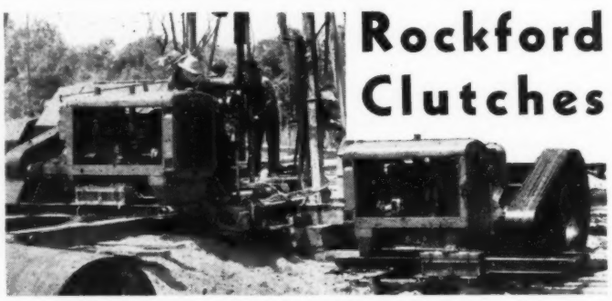


Rockford Clutches

Specified For Best Results In Oil Field Equipment

Over-Center Clutch

Spring-Loaded Clutch

Power Take-Off

Leading manufacturers specify Rockford Clutches for best results in tractors, power units, and other equipment used in oil well and pipeline work. Reasons for this include excellence of design, materials, workmanship, and engineering cooperation. Long highly successful service in a wide variety of industries proves that Rockford Clutches are notably powerful, durable, economical; and reliable under all operating conditions. Whether you buy or build oil field equipment, specify Rockford Clutches for best results; and write today for complete information on features, advantages, specifications.

Rockford Drilling Machine Divison Borg-Warner Corporation
▼ 1303 Eighteenth Avenue, Rockford, Illinois, U. S. A. ▼

Pullmore Multiple-Disc Clutches • Over-Center and Spring-Loaded Clutches • Power Take Offs

Book Reviews

Oil Well Drainage, by Stanley C. Herold, published by Stanford University Press, Stanford University, California. 407 pp. Price $5.00.

This is a practical book written for the layman in an easy readable style, fully supported by actual citations of field examples, expressly for geologists, engineers, landowners, leaseholders, and operators of producing oil and gas properties, for they meet directly the technological and financial issues of the industry. It is confined to the problem with which they are primarily concerned—drainage.

The results of 12 years' experience is contained in the book, during which time the author verified the mathematical theory of well and reservoir performance previously presented in *Analytical Principles of the Production of Oil, Gas, and Water from Wells.*

●

Handbook of Chemistry and Physics, 25th Edition, 1941-1942, published by The Chemical Rubber Company, 2310 Superior Avenue, Cleveland, Ohio. 2531 pp. Price $3.50.

A collection and compilation of chemical and physical data for engineers, chemists, students, and others. There are five general divisions of subject matter in the handbook separated for convenience by divisional guides. Each guide contains an outline of the contents of the section. The first division consists of mathematical tables and occupies 272 pages. Division No. 2 is headed "Properties and Physical Constants" and has undergone complete revision. General chemical tables and specific gravity and properties of matter are the two general sections of tables in this division and have been extensively revised. Division 4 contains information on heat and hygrometry, sound, electricity, magnetism, and light. Division 5 is devoted to quantities and units, conversion tables, and miscellaneous tables, valuable for general use. Many extensive changes have been made in recent years in the handbook. Beginning with the 1939 edition and including the current issue, considerably more than half of the pages in the book have been added or completely revised and reset. The size of the book has also been increased.

W.P.R.A. to Meet in St. Louis, Missouri, March 25

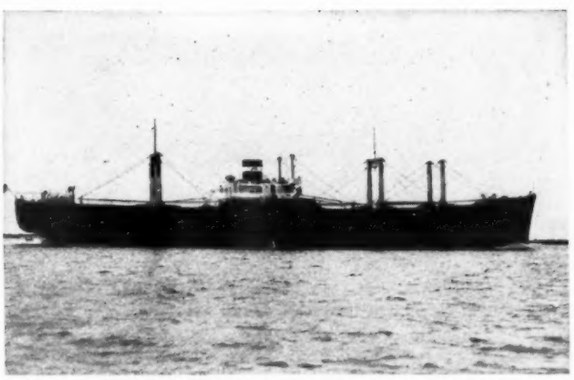
Arrangements have been completed for the 30th annual meeting of the Western Petroleum Refiners Association, according to J. C. Day, secretary-manager. This meeting will be held in St. Louis, Missouri, March 25, in the Jefferson Hotel. The first session will be called to order at 10 a. m., and, following luncheon, there will be an afternoon session beginning at two p. m. All business will be concluded in the single-day meeting.

First on the program will be the annual address by C. L. Henderson, president of the Association. A Nominating Committee will be appointed, and then will follow an extemporaneous talk on "The Importance of Refining in Wartime Economy," by Wright W. Gary, Director of Refining, Office of Petroleum Coördinator, Washington, D. C. At the conclusion of Gary's talk there will be a round table discussion.

The afternoon session will feature a talk on "Oil Transportation Under War Conditions," by Fayette B. Dow, Washington Counsel of the Association, and also Assistant Director, Office of Defense Transportation.

Report of the Nominating Committee, election of officers for the ensuing year, and the disposal of regular business will complete the day's deliberations.

Down to the sea in ships



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A long history of successful operation is behind the present trend to Fluid Drive for marine Diesel applications. American Blower Fluid Drive is playing a vital role, too, in trucks, locomotives, bridges, oil drill rigs, power plants, excavators, conveyors, etc. Alert, resourceful American industry is, in fact, utilizing Fluid Drive in new and improved products, in ways never dreamed of but a few years ago. Have you investigated Fluid Drive?

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HYDRAULIC COUPLING DIVISION
DETROIT, MICHIGAN
Division of AMERICAN Radiator and "Standard" Sanitary Corporation

Precision is the watch word of patriotic industry in America. Speed without precision is time lost

Greater Pecision for Better Production

At JENSEN BROTHERS the instruments of precision are held priceless. They are the keys to economy in critical materials and to the success of JENSEN UNITS in the field. You can *depend* on a JENSEN UNIT to cut production costs and minimize upkeep for the duration, because it's made right. We build 23 years of experience into every unit.

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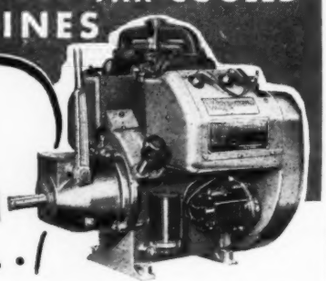
WISCONSIN HEAVY-DUTY AIR-COOLED ENGINES



In Step with TODAY'S INCREASED PRODUCTION DEMANDS . . .

In war service and in essential industries, both men and machines have to deliver more today than ever before. The inbuilt capacity to keep on "taking it", no matter how tough the going . . . is a prime requisite to winning this war.

It is because Wisconsin heavy-duty AIR-COOLED Engines (1 to 35 hp.) have this characteristic to a marked degree . . . that they can help YOU keep step with today's demands for *increased productive capacity*. You can *depend* on Wisconsin Engines . . . supplied as standard power equipment by more than 300 machine manufacturers . . . serving the Oil Industry as well as many others.

Write to HARLEY SALES CO., 510 Atlas Bldg., Tulsa, Okla., or M. & M. Bldg., Houston, Texas

Oil Field Distributors for Wisconsin Engines and All Types of Utility Units.

MOST POWER Per POUND

WISCONSIN MOTOR Corporation

MILWAUKEE, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

TRADE LITERATURE

What to Write For

THE PLOMB TOOL COMPANY, 2209 Santa Fe Avenue, Los Angeles, California, announces publication of its 1942 catalog containing listings of over 1200 kinds of fine forged hand tools, for use in all industries. Lithographed in three colors, the catalog totals 116 pages and features large and detailed illustrations of all items in the Plomb line. This catalog will be mailed free on request.

HELP IN DETERMINING the equipment need in plants to give it wartime emergency first-aid protection to meet civilian defense recommendations, is contained in a free leaflet just issued by E. D. Bullard Company, safety equipment manufacturers, 275 Eighth Street, San Francisco, California, and will be sent on request by the reader. The leaflet also describes personal protective equipment recommended for air-raid wardens, and some items, such as air raid sirens, for plant protection.

A BULLETIN on the Wright Speedway Electric Hoist is just off the press. It contains complete information and imparts inside facts on the many features of this low-cost electric hoist. The new light-weight electric hoist was recently added to the line by the Wright Manufacturing Division of the American Chain and Cable Company, Inc., York, Pennsylvania. The company will send a copy of the bulletin on request.

DOWELL INCORPORATED, Midland, Michigan, has released a new folder on the acid jet gun fully explaining the latest developments of the tool, features, and the advantages and benefits to be derived from its use. Eight distinct uses and actual data on acidized wells where the acid jet gun was used are cited in the folder. This enlightening information may be obtained free of charge by making request to the company. Write for folder 5M.

THE WIRE ROPE DIVISION of the Jones and Laughlin Steel Corporation has recently published a useful booklet entitled "Rotary Line Service Record." This booklet was prepared for oil drillers and contractors for the convenience of keeping a service record on the wire rope they use. Charts are included to assist in determining the ton-miles of wire rope service that result from trips in drilling operations and in setting casing or running tubing. A copy of this booklet may be obtained by writing to the Jones and Laughlin Steel Corporation, Wire Rope Division, Pittsburgh, Pennsylvania.

A NEW BULLETIN, "Ropeology," has been released by the Macwhyte Company, Kenosha, Wisconsin, manufacturers of wire rope, and is available to readers on request on company letterhead. The bulletin contains a description of the uses of wire rope, care, and methods of application. Complete data on selection of the right size and qualifications of the wire rope for each job are included.

A NEW BOOKLET describes a compact and highly efficient mechanism for heating or cooling of liquids and viscous materials, which also offers mixing, emulsifying or aerating simultaneous with heating or cooling. The unit is known as the Votator. Helpful charts, diagrams, cross-sections, and reference tables are included in the booklet. For a copy address The Girdler Corporation, Votator Division, Louisville, Kentucky.

MARMON-HERRINGTON COMPANY, INC., Indianapolis, Indiana, are releasing their latest catalog on the specifications of their all-wheel drive trucks, commercial cars, and passenger cars. The company will send without obligation a copy of the catalog on request.

A CATALOG describing the Masoneilan pipe-line controls, including pressure controllers, regulating valves, control valves, flow meters, and controllers will be sent on request of the reader. Address Mason-Neilan Regulator Company, 1187 Adams Street, Boston, Massachusetts.

READERS are urged to write for the catalog offered by Naylor Pipe Company on Naylor line pipe that conserves steel by its light weight and includes the exclusive Lockseam Spiralweld that is said to provide extra strength. Address Naylor Pipe Company, 1240 East 92nd Street, Chicago.

ARMSTRONG BROS. TOOL COMPANY will send their complete catalog C-39, showing its complete line of pipe tools. Address Armstrong Bros. Tool Company, 331 North Francisco Avenue, Chicago, Illinois.

ILLUSTRATED BULLETIN 102 contains complete information and data on B and W wall cleaning guides and will be sent without obligation, on request. Address B and W, Inc., 3545 Cedar Avenue, Long Beach, California.

THE 44-PAGE CATALOG of useful and valuable information in the Catalog M-3 issued by The France Packing Company, Tacony, Philadelphia, Pennsylvania, will be sent on request.

CYCOIL BULLETIN No. 130D gives complete information on the operation of the Cycoil engine air cleaners. The company urges readers to write for this book of facts on how Cycoils save money and keep engines running perfectly longer. Address American Air Filter Company, Inc., 384 Central Avenue, Louisville, Kentucky, for your copy.

A CATALOG containing a full description of the K and E Wyteface "A" steel tape manufactured by Keuffel and Esser Company, New York, New York, will be sent on request of the reader.

THE VARIOUS APPLICATIONS of the Quill Bearing, manufactured by Bantam Bearings Corporation, South Bend, Indiana, are given with other information on this "compact, high-capacity" bearing in Bulletin P-104. The bulletin will be sent on request without obligation.

BULLETIN 1079, released by the Waukesha Motor Company, Waukesha, Wisconsin, contains a description of the Waukesha engines of power hoists, drawworks for servicing or drilling wells, and other oil-field services. Copies of this bulletin will be sent on request.

AXELSON RESUMES PUBLICATION OF HOUSE ORGAN. Announcement has been made by The Axelson Manufacturing Company, 6160 South Boyle Avenue, Los Angeles, California, to the effect that the *Axelson Contact* has resumed publication and is being sent to employees, stockholders, and customers of the company. Revival of this house organ by the company is in recognition of the changes the world is undergoing at the present time, it is stated. According to the announcement, "With the world at war, a closer understanding on the part of Axelson's customers of the problems which confront our organization is most vital. Likewise, a better understanding by stockholders, employees, and by industry at large is essential if Axelson is to maintain in the future the progressive record of development and enterprise which has characterized its operations for the last 50 years."

HELP WIN THE WAR!

By SAVING Time...Effort...Materials Wherever Possible

FOR EXAMPLE:

CLEANING HEAT EXCHANGERS FASTER... EASIER

Keep the planes flying, tanks rolling and ships sailing for Victory! As the "order of the day", it means that producing and refining equipment must work longer, operate better... that required maintenance work is done easily, quickly.

That is why we say... clean your heat exchangers FASTER and EASIER the successful, simple Oakite way! No dismantling required. Just circulate recommended Oakite solution through the units as directed. Insulating lime-scale, carbonized oil or sludge deposits are thoroughly removed. Normal heat transfer is restored, output increased. Units are back in service quickly. Complete data FREE on request. Write today.

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OAKITE PRODUCTS, INC., 48 Thames St., New York

Representatives in All Principal Cities of the U. S. and Canada

OAKITE Specialized CLEANING

MATERIALS METHODS SERVICE FOR EVERY CLEANING REQUIREMENT

For SAFE VIBRATION-PROOF FASTENINGS on OIL FIELD EQUIPMENT

Elastic Stop Self-locking Nuts put an end to maintenance troubles resulting from loose fastenings. They can not be loosened by vibration, shock loads, or exposure to weather. Available in all standard types and sizes.

SPECIFY THEM ON NEW EQUIPMENT AND USE THEM FOR REPLACEMENT

Sold by leading supply houses.
Factory stocks in Houston and Los Angeles.

Catalog contains a graphic explanation of the Elastic Stop principle, presents test and application data, illustrates uses, and lists the complete line of nuts • Write for a copy.

Also see data in Composite Catalog.

ELASTIC STOP NUT CORPORATION
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Elastic Stop SELF-LOCKING NUTS

"The nation now, as in 1917, will need the wholesome tonic of recreational travel as one of the greatest maintaining forces of national morale."—Statement by United States Travel Bureau of the U. S. Department of the Interior.

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WE'RE DOING
Our Part...

★ ★

HOTELS of Southern California are doing their part in this great national cause by maintaining normal facilities and operations in every department for the use of Americans seeking mental and physical release from strain and fag.

To facilitate the business of Americans, and in the interest of war production, there is augmented service at the great metropolitan hotels of Los Angeles, Hollywood, Long Beach, San Diego and the other large cities of Southern California.

There are no rations of fun at the fine resort hotels located on the desert at Palm Springs; by the sea at Coronado, Carlsbad, Laguna, La Jolla, Santa Catalina, Santa Monica and Santa Barbara; and amid the beauties of Pasadena, Beverly Hills and Riverside. Health and energy still bubble from the earth at the famous mineral springs resorts.

Golf, tennis, riding, cycling, badminton and a multitude of other sports and recreations are still to be enjoyed every day of the year by the visitor to this sun-blessed land.

Hotel rates in Southern California will continue at pre-war levels. Nowhere is there a greater variety of hotel accommodations to suit every budget and every taste.

In spite of rumors, travel is *normal in Southern California. Transportation to and throughout the state* is *normal, and hotel and resort life* is *normal.*

For further particulars, consult the nearest travel or transportation agent or your automobile club.

Hotels

OF SOUTHERN CALIFORNIA

Room 701, 629 South Hill Street, Los Angeles, California.

Bethlehem Supply Adds Superior Engines to Its Line

To facilitate the handling of increasing sales and to broaden the service rendered to many present operators, Superior gas and Diesel oil-field engines have been added to the line of oil-field equipment sold by the Bethlehem Supply Company.

Left to right—W. F. Freeman, National Supply Company; A. G. Weber, J. R. James, J. F. Eaton, R. A. Johnson, H. A. Barnes, B. E. Groenewold, Bethlehem Supply Company; H. M. Houston, National Supply Company, and V. D. Bennett, Bethlehem Supply Company

Under supervision of Arch F. Campbell, sales manager of the Superior Engine Division of the National Supply Company, an enthusiastic and very successful 6-day meeting was recently held at the Superior factory at Springfield, Ohio.

Left to right—Arch F. Campbell, George W. Stevens, National Supply Company; D. C. Laughlin, T. W. Thurmond, George L. Reid, A. G. Vielhover, K. N. Mills, Bethlehem Supply Company; H. M. Cahill, National Supply Company; B. E. Groenewold, I. V. Spaulding, and F. A. Holmberg, Bethlehem Supply Company

Bethlehem salesmen attending the meeting were under the direction of B. E. Groenewold, manager, Machinery Department, Bethlehem Supply Company.

The National Supply Company and Bethlehem Supply Company men who attended the sales meeting are shown in the accompanying photographs.

MEETINGS

Wisconsin Petroleum Association, Annual Convention and Equipment Show—March 18, 19 and 20, Schroeder Hotel, Milwaukee, Wisconsin.

American Society of Mechanical Engineers, Spring Meeting—March 23, 24, and 25, Houston, Texas.

Western Petroleum Refiners Association, 30th Annual Meeting—March 25, Jefferson Hotel, St. Louis, Miissouri.

American Petroleum Institute, Division of Production, Mid-Continent District, Spring Meeting—March 26 and 27, Mayo Hotel, Tulsa, Oklahoma.

California Natural Gasoline Association, Monthly Meeting — April 5, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

American Petroleum Institute, Division of Production, Eastern District, Spring Meeting—April 9 and 10, William Penn Hotel, Pittsburgh, Pennsylvania.

Midwest Power Conference, Annual Meeting—April 9 and 10, Palmer House, Chicago, Illinois.

American Institute of Mining and Metallurgical Engineers—April 15, 16, and 17, Cincinnati, Ohio.

National Petroleum Association, Thirty-ninth Semi-Annual Meeting—April 16 and 17, Hotel Cleveland, Cleveland, Ohio.

American Chemical Society, 103rd Meeting—April 20, 21, 22, 23, and 24, Memphis, Tennessee.

Southwestern Gas Measurement Short Course—April 21, 22, and 23, University of Oklahoma, Norman, Oklahoma.

American Association of Petroleum Geologists, Twenty-seventh Annual Meeting—April 21, 22, 23, and 24, Cosmopolitan Hotel, Denver, Colorado.

Petroleum Industry Electrical Association—April 22, 23, and 24, Shreveport, Louisiana.

The American Association of Petroleum Geologists, The Society of Economic Paleontologists and Mineralogists, The Society of Exploration Geophysicists, and The Rocky Mountain Association of Petroleum Geologists, joint Annual Convention — April 22, 23, and 24, Cosmopolitan Hotel, Denver, Colorado.

American Gas Association, Natural Gas Section, Annual Convention—May 4, 5, 6, and 7, New Orleans, Louisiana.

American Institute of Chemical Engineers—May 11, 12, and 13, Boston, Massachusetts.

Natural Gasoline Association of America—May 13, 14, and 15, Mayo Hotel, Tulsa, Oklahoma.

American Petroleum Institute, 12th Mid-Year Meeting—May 25, 26, 27, 28, and 29, Oklahoma City, Oklahoma. (Cancelled)

American Society of Mechanical Engineers, Semi-Annual Meeting—June 8, 9, 10, and 11, Cleveland, Ohio.

American Society for Testing Materials—June 22, 23, 24, 25, and 26, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

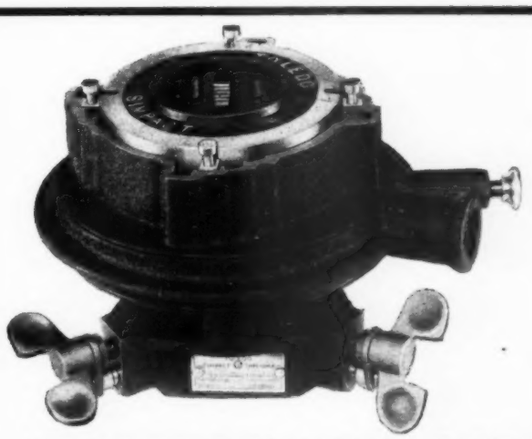
Texas Mid-Continent Oil and Gas Association—October 8, 9, and 10, Dallas, Texas.

American Society of Mechanical Engineers, Fall Meeting—October 12, 13, and 14, Rochester, New York.

National Lubricating Grease Institute, Tenth Annual Meeting—October 25, 26, 27, 28, and 29, New Orleans, Louisiana.

Illinois Mineral Industries Conference—October 30 and 31, Urbana, Illinois.

American Petroleum Institute, Annual Meeting — November 9, 10, 11, 12, and 13, Chicago, Illinois.



"TOLEDO" SIMPACT FOR 1 TO 2 INCH PIPE

Self contained. Threads 1" to 2" pipe with one set of high-speed steel dies. No bushings. Easy, accurate centering. Sizes are changed quickly and accuracy is always maintained. Long handle gives ample leverage.

Specify a "TOLEDO" SIMPACT. Order from your nearest supply house.

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WATER CANS
& COOLERS
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GOTKOOL WATER COOLER
GOTT Water Cans are the practical way to keep drinking water cool for long periods, protected from impurities and always handy to the job. Snug fitting large removable top, strongly built to withstand rough usage. GOTT Water Coolers have extra large covers and a handy non-leaking push button faucet. Your Supply Store has them, get one today! . . . . .
H. P. GOTT MFG. CO.
WINFIELD KANSAS
KEEP PURE DRINKING WATER ALWAYS HANDY

"WANTED"

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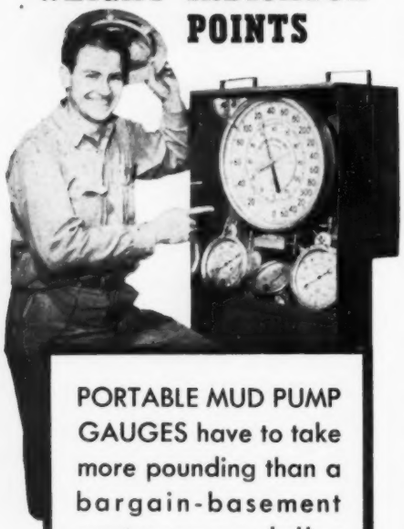
WEIGHT INDICATOR POINTS



PORTABLE MUD PUMP GAUGES have to take more pounding than a bargain-basement customer on dollar day, what with violent pump pulsations, vibrations, high pressures and all.

Can they stand it? If it's a Martin-Decker Unitized Gauge, you needn't worry. In this gauge you get *sensitivity* over the entire pressure range . . . accuracy to the pound . . . and smooth, easy-to-read gauge hand movement. (You can tell pressure by position of the hand, even *when you can't read figures on the dial.)*

And yet this laboratory-accurate gauge has ample oil field ruggedness for years of trouble-free service on well after well!

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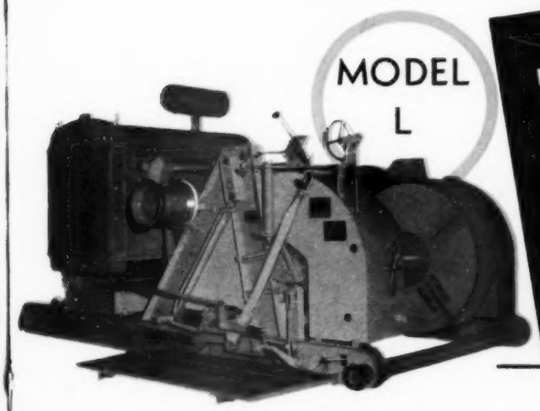
Index to Advertisers

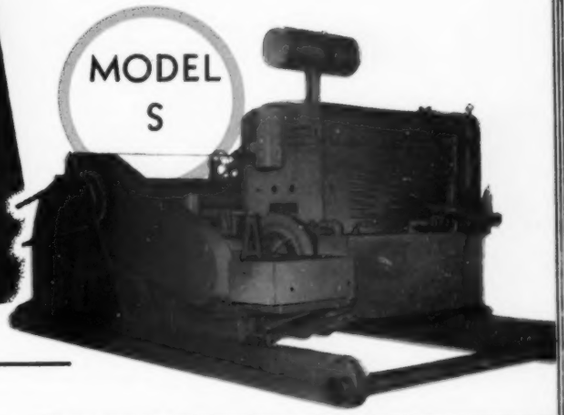
Affiliated National Hotels 205
Air Reduction Co., Inc.
American Air Filter Co., Inc. 193
American Blower Corp. 209
American Cable Division of American Chain and Cable Company, Inc. ..... Inside Back Cover
American Chain & Cable Company, Inc. ..... Inside Back Cover, 47 and 157
American Hammered Piston Ring Division
American Meter Company 52
American Roller Bearing Co.
American Sand-Banum Co., Inc. 201
Armstrong Bros. Tool Co. 201
Axelson Manufacturing Co. 2
B and W, Inc. 10
Baash-Ross Tool Co. 67
Baker Oil Tools, Inc.
Baldwin De La Vergne Sales Corp. 25
Bantam Bearings Corp. 170
Baroid Sales Co. 185
Barrett Co. 139
Bartlett-Hayward Division
Bethlehem Supply Co. 153
Black Construction Co. 145
Braden Steel Corp. 95
Brown Instrument Co. 57
Buckeye Traction Ditcher Co. 97
Bullard, E. D., Co. 206
Byron Jackson Co. 119
Cameron Iron Works 65
Cardwell Mfg. Co. 1
Case, J. I., Co. 194
Chapman Valve Mfg. Co., The 8
Chicago Bridge & Iron Co. 19
Chiksan Tool Co. 205
Clark Bros. Co. 54-55
Cleveland Trencher Co. 107
Climax Molybdenum Co.
Continental Motors Corp. 198
Continental Supply Co., The 189
Cook, C. Lee, Mfg. Co. 176
Cooper-Bessemer Corp. 37
Crane Co. 4
Cummins Engine Co. 187
Dearborn Chemical Co. 111
Dempsey, O. E., Construction Co. 136
Dowell Incorporated 21
Dresser Manufacturing Co. 86
Elastic Stop Nut Corp. 211
Electro Metallurgical Co.
Emsco Derrick & Equipment Co.
Ensign Carburetor Co., Ltd. 208
Fluid Packed Pump Co. ..... Front Cover
Fluor Corp., Ltd. 126
Foster Cathead Co. 206
Foxboro Co., The
France Packing Co. 202
Frick-Reid Supply Corp.
Gaso Pump & Burner Mfg. Co. 88-89
Gearench Mfg. Co. 195
General Paint Corp. 142
Gott, H. P., Mfg. Co. 213
Graver Tank & Mfg. Co., Inc. 93
Grizzly Manufacturing Co. 196
Gulf States Utilities Co. 144
Gustin-Bacon Mfg. Co. 79
Halliburton Oil Well Cementing Company ..... Back Cover
Haynes Stellite Company
Hazard Wire Rope Division of American Chain and Cable Co., Inc. 157
Hill, Hubbell & Co., Division 142
Hotels of Southern California 212
Hughes Tool Co. 49
Hunt Tool Co. 159
Hyatt Bearings Division, General Motors Sales Corp. 182
Industrial Engineering Co. 70
Jacobs Wind Electric Co. 136
Jarecki Mfg. Co. 161
Jensen Bros. Mfg. Co. 210
Johns-Manville Corp.
Jones & Brooks, Inc. 133
Jones & Laughlin Steel Corp. 109
Kerotest Mfg. Co. 125
Keuffel & Esser Co. 59
Kobe, Incorporated 7
Koppers Company
American Hammered Piston Ring, Division, Bartlett Hayward Division, Engineering and Construction Division, Western Gas Division, Wood Preserving Corp., The
Lane-Wells Company 11
Larkin Packer Co., Inc. 41
LeRoi Company 174
Leschen, A., & Sons Rope Co. 15
Lincoln Electric Co.
Linde Air Products Co., The 85
Link-Belt Co. 151
Lone Star Cement Corp. 45
Lufkin Rule Co. 204
Lunkenheimer Co., The
McEvoy Company 201
Macwhyte Company 3
Marmon-Herrington Co. 75
Marsh, Jas. P., Corp.
Martin-Decker Corp. 214
Mason-Neilan Regulator Co. 123
Mayes Bros., Inc. 105
Merco Nordstrom Valve Co. 81-82
Mission Mfg. Co. 146
National Carbon Company, Inc. 103
National Supply Co., The 68
National Tube Co.
Naylor Pipe Company 143
Oakite Products, Inc. 211
Ohio Injector Company 101
Oil Center Tool Co.
Oil Well Supply Co.
Otis Pressure Control, Inc. 203
Patterson-Ballagh Corporation
Penberthy Injector Co. 17
Petroleum Electric Power Assn. 62-63
Petroleum Rectifying Co. 121
Pittsburgh Equitable Meter Co. 166
Price, H. C., Co. 113
Reading-Pratt & Cady Division of American Chain & Cable Co., Inc. 47
Rector Well Equipment Co., Inc. 163
Reed Roller Bit Co. 26
Reilly Tar & Chemical Corp. 132
Republic Steel Corp. ..... Inside Front Cover
Ridge Tool Co. 165
Rockford Drilling Machine Division 208
Roebling's, John A., Sons Co.
Schlumberger Well Surveying Co.
Sheehan Pipe Line Construction Co. 135
Skinner, M. B., Co. 115
Smith, A. O., Corp. 155
Southwestern Gas & Electric Co. 145
Spang & Co. 129
Spang Chalfant, Inc.
Sperry-Sun Well Surveying Co. 12
Staynew Filter Corp. 178
Stearns-Roger Manufacturing Co. 51
Taylor Forge & Pipe Works 43
Texaco Development Corp.
Toledo Pipe Threading Machine Co. 213
Tretolite Co. 117
Tube-Turns, Inc. 39
Twin-Disc Clutch Co. 197
Union Carbide and Carbon Corp. 85
Union Wire Rope Corp. 200
United Gas Pipe Line Co. 141
Universal Atlas Cement Co. 9
Vogt, Henry, Machine Co., Inc.
Vortox Manufacturing Company 207
Wailes Dove-Hermiston Corp. 130
Wall-Colmonoy Corp. 199
Waukesha Motor Company 172
Whitney Chain & Mfg. Co., The 180
Williams, J. H., & Co. 13
Williams Bros. Corp. 98
Wilson Supply Co. 23
Wisconsin Motor Corp. 210
Worthington Pump & Machine Corp. 91
Wyatt Metal & Boiler Works
Young Radiator Co. 207
Youngstown Sheet & Tube Co. 5

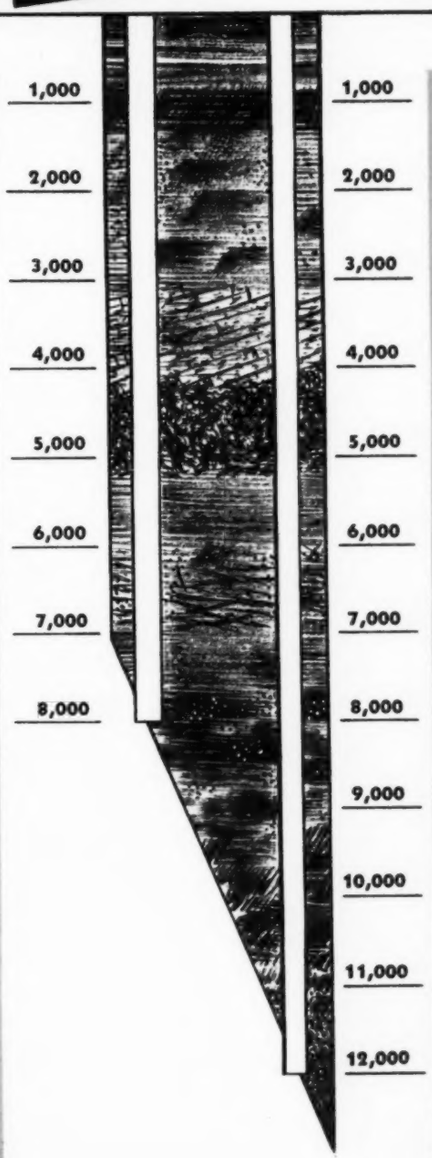
WHY BUY A SKID TYPE HOIST FOR DEEP WELL SERVICING?



Here's the answer from a prominent servicing contractor:

"Servicing wells at 6,500 feet, my 'Cardwell' skid type hoist makes two trips per hour on bailing jobs. A truck power take-off hoist, rated at the same capacity, makes only four trips every three hours. This information is based on records kept by the major oil companies. As a result, I'm getting more jobs for my 'Cardwell' hoists."





The Whole Reason:

Plenty of power for deep well servicing can be used on a "Cardwell" skid type hoist. The truck power take-off arrangement is always limited to a medium-size power unit because of the torque capacity of the truck rear axle, but the skid type hoist can be furnished with sufficient power to pull the load at the proper speed. The engine drives direct to the hoist through a heavy-duty transmission that will take the full engine capacity. This direct drive, through spur or helical gears, eliminates wasted horsepower and uses practically all the power of the engine.

Model S, for well servicing to 12,000 feet, is available with engines up to 202 HP; Model L, for well servicing to 8,000 feet, with engines up to 175 HP. The skid type hoist and separate truck save on initial investment and increase the usefulness of each unit. The hoist can be on a servicing job while the truck is used elsewhere.

The rotary table drive assembly, as illustrated, makes these hoists practical for workover jobs to the same depths as shown for servicing.

FEATURES

The dual safety braking system operates with one-half the ordinary pressure and enables either brake to operate independently and hold the load should the other be damaged. Brake flanges, with a water trough that will not clog, are fabricated of special alloy steel and heat-treated for toughness and hardness.

Positive jaw clutches and SKF self-aligning bearings insure a free-rolling drum.

Compact, lightweight construction makes these hoists easy to transport and operate on a truck or trailer.

Extensive use of alloy steels keeps weight at a minimum.

Heat-treated wearing parts insure long life with little down time and maintenance expense.

Single and double leg telescoping servicing masts are available.

Write us for full information on our four sizes of double drum hoists for servicing from 2,500 to 10,000 feet with either rotary or spudder assemblies.

CARDWELL ALL STEEL
THIS TRADE MARK INSURES HIGHEST QUALITY AT LOWEST PRICE

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"CARDWELL" RIGS ARE STRONGER, WEAR LONGER AND WEIGH LESS

AXELSON PUMPS SAVED ME $20,000 LAST YEAR

There was a time when I bought Axelson Pumps because usually A's increased the production of wells in which they were run. Little over a year ago I was put in charge of this lease. With proration setting the pace, more production didn't interest me last year, but still I saved the company money by insisting on Axelson's Pumps. How did I do it? It was a cinch three-way bet.

First, I cut power costs on the prorated production. How? Because when you run Axelson Pumps there's a size and type to most efficiently meet actual well conditions. No reason to use power operating a big expensive pump capable of producing 300 barrels a day when a pump half the size and cost will do the job as well.

Second, I reduced oil emulsion and gas locks. Doing this reflected a lower dehydrating cost before the crude went into field storage. Third, because of the high quality material and skilled workmanship that goes into every Axelson Pump I was able to save thousands of dollars in pulling costs. You know that when a plunger sticks or a valve goes haywire you've still got a pulling job regardless of whether you're pumping 50 or 250 bbls. of crude a day.

When the savings for all three items were added up, my lease showed a saving in operating costs of over $1600 per month. That don't hurt my record in the head office and it wouldn't hurt yours if you did the same thing.

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AXELSON SELLS & *SERVICES* DEEP

WELL PLUNGER PUMPS AND SUCKER RODS

3 ways to make your Wire Rope dollar go farther...conserve steel tonnage too

(No. 9 in a series of informative articles for wire rope users prepared by the Macwhyte Wire Rope Company. Previous articles in this series are available on request on your company letterhead.)

1 Buy PREformed; it's best, costs less

There have always been sound reasons for buying PREformed wire rope. Careful tests time and again have proved it gives better service than non-preformed, costs less in the long run, saves time because fewer shutdowns are necessary for replacements.

Fig. A — PREformed ropes are free of internal stress, have high fatigue resistance.

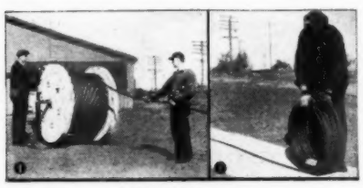
Today there's another reason why it's most important to buy PREformed: by doing so you help national defense.

It takes just as long at the steel mill to make steel for non-preformed as for PREformed wire rope. Yet PREformed will outlast ordinary wire rope on most jobs. When you buy Macwhyte PREformed, therefore, you're helping conserve not only steel which America greatly needs, but also the time of those who make it.

2 Install Rope Carefully

It's so easy to kink or twist rope when installing in a hurry. Such "haste makes waste." Kinking and twisting definitely shortens rope life.

With reasonable care and speed you can prevent both. Here are some simple suggestions on unreeling and uncoiling rope . . . operations where both kinking and twisting are apt to occur.



CORRECT WAY

Unreeling—The reel should be revolved and the rope taken off the way it is put on the reel. Illustration No. 1 shows one method—put a shaft through the center of the reel and jack it up so that the reel will revolve freely. Pull the rope straight ahead, keeping it taut to prevent it from loosening up on the reel. A board held against one flange may be used as a brake to keep the reel from revolving too fast.

Uncoiling—Roll the coil along the ground so the rope lies straight as shown in Illustration No. 2. There will be no twist or kink in the rope if these instructions are followed.

INCORRECT WAY

Illustrations 3 and 4 show incorrect ways of unreeling and uncoiling. Notice that the reel and coil cannot revolve and therefore the rope is twisted as each turn is taken off.

3 Inspect Your Ropes Regularly

Once wire rope is on their equipment many users overlook the value of regular inspection. Such negligence is costly. It can be avoided by regular inspection which takes far less time, is much less expensive than too frequent buying and replacing for lack of knowledge of their condition.

Pictured here are a few of the most common "Wire rope enemies" which, if *not* eliminated or kept under control, can easily reduce the service life of your rope as much as 50%. Also given here are suggested methods of avoiding these dangers.

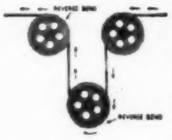


Fig. B — Reverse bends— Years of experience and many tests have proved that reverse bending and excessive wire fatigue reduce rope life as much as 50%.

Where reverse bending cannot be eliminated, use the largest sheaves possible and place them as far apart as possible. By getting the MAXIMUM distance between reverse bends, you reduce fatigue—provide longer service.

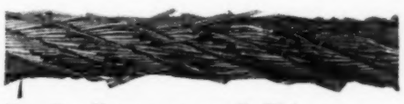


Fig. C—Sheaves too small. This rope was forced to travel continuously over sheaves whose diameters were too small. Frequent inspection would have shown this danger. A change to a larger sheave would have solved the problem. (Note: PREformed wire rope would have lasted much longer in this case.)

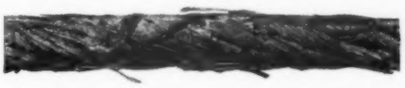


Fig. D—Drum abrasion and abuse caused this. The rope was scuffed over and over against previous wraps on a flat-faced drum. This could have been prevented by even winding and grooved drums.

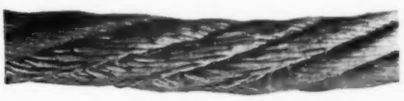


Fig. E—Kinking caused this. This dog-leg, or kink, was finally straightened out . . . but notice the uneven wear at the point where the kink had been. Proper handling during installation could have prevented this. Beware of dog-legs! They're expensive.

Why Guess? When you can KNOW!

Macwhyte Company wants you to know that they will be glad to offer recommendations of the correct ropes for your equipment and, if you like, discuss with you possibilities of getting more from the ropes you are using . . . should there be any doubt in your mind as to whether you are getting the best service.

Internally Lubricated — made with 2 kinds of wire — Laboratory Tested —Field Proved

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2942 Fourteenth Avenue · Kenosha, Wis.

Manufacturers of Wire Rope to meet every need—left-&-right-lay braided slings—stainless steel wire rope—monel metal wire rope—aircraft cable, aircraft tie-rods, and "Safe-Lock" cable terminals.

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2 HELP YOU Get Better Service from Valves and Fittings

Today's situation calls for *round-the-clock* production. That means your plant must get *better* service from valves and fittings, and have *better*-trained men to keep piping on the job. Crane Shop Bulletins for maintenance workers are aimed to help you get both. Their wealth of practical pointers aids in guiding *new* men, as well as assists veteran crews in stepping up efficiency of piping equipment.

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11 SIMPLE WAYS TO GET BETTER SERVICE FROM PIPING EQUIPMENT
TIPS ON VALVE TRIM
TO HELP KEEP PIPING ON THE JOB
PLEASE CHECK AND PASS ON
IT'S THE TRIM THAT COUNTS!
HELPFUL HINTS ON CHOOSING VALVES FOR BETTER PIPING SERVICE
HOW TO KEEP YOUR PLANT GOING WITHOUT INTERRUPTION!

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VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

The Petroleum Engineer, published monthly, August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, seventh floor Allen Building, Dallas, Texas. Subscription price, $2.00 per year, $3.00 for 2 years, 25c a copy. Entered as second-class mail matter May 1, 1932, at the post office at Dallas, Texas, under the Act of March 3, 1879.

You cannot really know the advantages of the Kobe Hydraulic Pumping System until you've tried it. Every day more operators are turning to this modern system of producing oil, as illustrated by the rapidly increasing number of installations being made.

You will be agreeably surprised by the many new ways that Kobe multiple pumping will help you—to obtain lower installation costs — to produce your wells better — to reduce and keep operating costs down — to increase or decrease volumes as changing conditions or emergencies may require — other ways too numerous to list here.

To *know* you know your pumping problems is a mighty satisfactory feeling. Be sure *you* know how Kobe can help you by checking this modern system on your own pumping equipment needs. The Kobe Technical Service Department's wide experience in pumping problems is available to help you in every possible way. Call the nearest Kobe representative and get the facts.

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HYDRAULIC PUMPING SYSTEM

Quit Wildcatting in Small Valves

STANDARDIZE ON THIS DEADSHOT TROUBLE-SHOOTER

CHAPMAN List 960

No need to sink money in testing here, there and everywhere for small valves that are dependable "producers" of uniform, trouble-free service. Everything you're looking for is ready and waiting for you in one valve . . . Chapman 960 . . . *on which the testing has all been done.*

This tough forged-steel gate valve is designed and built to last for years, on all small field and refinery lines up to 2". It always works (without forcing) for the quick-acting threads can't stick. And the interchangeable stem, wedge and seat rings are stainless steel . . . super hardened by a special process . . . which means *plus-protection* against any troubles arising from wear, and longer life than any other similar type of small valve. List 960 is made in outside and inside screw models, for pressures up to 800 lb. at 750° F., and cold working pressures up to 1500 lb.

The Chapman Valve Mfg. Co., Indian Orchard, Mass., U.S.A.

PERMITS HEAVIER SLURRY!

Improved Unaflo—the retarded oil-well cement—requires a minimum of mixing water; yet, resulting slurry remains fluid and pumpable for extended periods under different hole temperatures and pressures.

WITH *improved* Unaflo, your slurry may be just as heavy as your pumps will pick it up from the mixing tub—because *improved* Unaflo's retarded set keeps the slurry fluid and pumpable for extended periods.

Advantages of Heavier Slurry

The introduction of Unaflo *retarded* cement brought about several important improvements in cementing. With cements that begin to stiffen when water is added and that stiffen more rapidly as the temperature increases, light, 13-lb. slurries often were used to maintain pumpability. With Unaflo *retarded* cement, practice shifted to the heavier, better and stronger 16- and 17-lb. slurries. These heavier slurries have several advantages. For example, a heavy Unaflo slurry that remains fluid and pumpable—

1. Behaves like a good rotary mud in following irregularities of well bore and casing couplings;

2. Flushes ahead of it the lighter, rotary mud without breaking the mud seal;

3. Does not become contaminated with the mud;

4. Produces back of the casing a more continuous body of good cement;

5. Results in a stronger . . . denser . . . more impervious seal.

Improved Unaflo Developed by Research

Despite the satisfaction Unaflo retarded cement gave upon its introduction, Universal Atlas was not satisfied. Research continued. The result is an *improved* Unaflo—even more uniform in composition, more uniform in reaction to different types of mixing waters found on different jobs, and more uniform in retardation of setting time under different hole temperatures and pressures. Use Unaflo, the *improved* retarded oil-well cement, to protect your investment in tools and well. Get it from your dealer.

Write for Your Copy of New Booklet, "Case Histories of Oil Well Cementing"... Let oil men tell you of their experiences with Unaflo Oil-Well Cement. See how these men saved time, money and costly equipment on actual cementing operations. Write Universal Atlas Cement Company (United States Steel Corporation Subsidiary), Amicable Building, Waco; Oklahoma City; Kansas City; Chicago; Birmingham.

You Get These Extras in Improved Unaflo

Characteristics	Advantages
Composition is more uniform.	Less mixing water required for sustained pumpability.
Reaction to different mixing waters found on different jobs is more uniform.	Stronger, denser, more impermeable seal is obtained with heavier slurry.
Retardation of setting time under different hole temperatures is more uniform.	Fluidity is maintained under different hole temperatures and pressures.
Stiffening of slurry is not merely "slow." It is delayed, postponed, retarded. It remains fluid and pumpable for period of retardation, then hardens normally.	Pumpability is maintained after shutdowns for extended periods.
	Factor of safety is higher.

PE-U-25

IMPROVED UNAFLO

A PRODUCT OF THE UNIVERSAL ATLAS CEMENT COMPANY

"To neglect

DEFENSE

is to invite Disaster . . ."

TRUE in our Nation - TRUE in Your Oil Well...

Vultee Vanguard Pursuit

B and W, Inc.

WALL CLEANING GUIDES

(Patents Applied For)

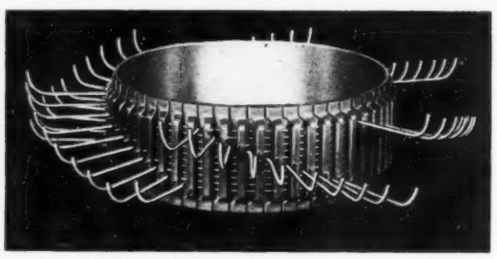
ARE YOUR DEFENSE AGAINST

FLUID MIGRATION

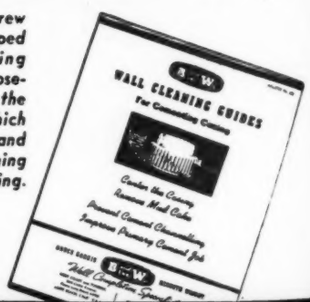
THE MOST INSIDIOUS "FIFTH COLUMN" in an oil well is the possibility of water or gas migration behind the casing — which becomes a probability when no precautionary measures are taken while cementing to remove obstructive mud cake and assure fluid-tight contact between cement and formation.

B and W Wall Cleaning Guides have proven to be the best defense against the faulty completions resulting from fluid migration. Rows of tempered spring steel wires with strong torque action are attached to collars which are mounted in series on the casing. The casing is moved up and down just before and during the final placement of cement. The wires have a direct abrading action on the mud cake, besides acting as centering guides for the casing, the final result being uniform cement distribution in a clean hole and DEFINITE DEFENSE AGAINST FLUID MIGRATION.

WELL-STRAINERS . . PRE-PACKED GRAVEL LINERS — Removal of mud cake from the producing section during completion is obtained by the B and W Completion Method (Patents Pending). Full information on request.



Top view above shows derrick crew starting to run casing equipped with B and W Wall Cleaning Guides . . . Lower view shows close-up of single Guide unit . . . At the right, our Bulletin No. 102, which contains complete information and data on B and W Wall Cleaning Guides . . . Yours for the asking.



WRITE FOR ILLUSTRATED BULLETIN 102

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Well Completion Specialists

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Doubly safeguarded against the dangers of pressure, Electrolog's steel-shrouded line and Lane-Wells Pressure Packing Gland give you extra safety factors to protect both the well and the crews.

Weight to get down - Strength to come out!

When the going gets thick Electrolog Cable has plenty of weight to pull itself to bottom—even in the heaviest muds. The safety pull-out head gives you maximum protection against expensive cable fishing jobs if the formation caves above the Electrode during a run.

— An "Eagle-eye" for detail —

Electrolog Galvanometers are precisely calibrated to assure accurate recording and sharpness of definition on all curves. They are tough enough to retain calibrations under widely varying operating conditions.

3 "REASONS WHY" YOU CAN RELY ON LANE-WELLS *Electrolog*

Electrolog equipment assures sharper, more sensitive logs of open hole formation. Electrolog crews are trained to get on and off the rig with a minimum of "down time." Oil well operators in every field can tell you with confidence that Lane-Wells Electrolog Service gives the best results under every operating condition. ¶ You can prove this for yourself. Just "call Lane-Wells" for your next Electrolog job. ***General Offices & Plant: 5610 South Soto St., Los Angeles, California.***

FAST EFFECTIVE DRILLING

IS A MUST THESE DAYS

SPERRY-SUN CAN HELP!

Wartime production carries a double load. It must deliver the goods to meet vastly increased requirements—*without waste of time or equipment.*

Inefficient drilling is as unpatriotic today as it is unprofitable in peace time.

Sperry-Sun Instruments and Services are at your call, to help you do the job our country asks.

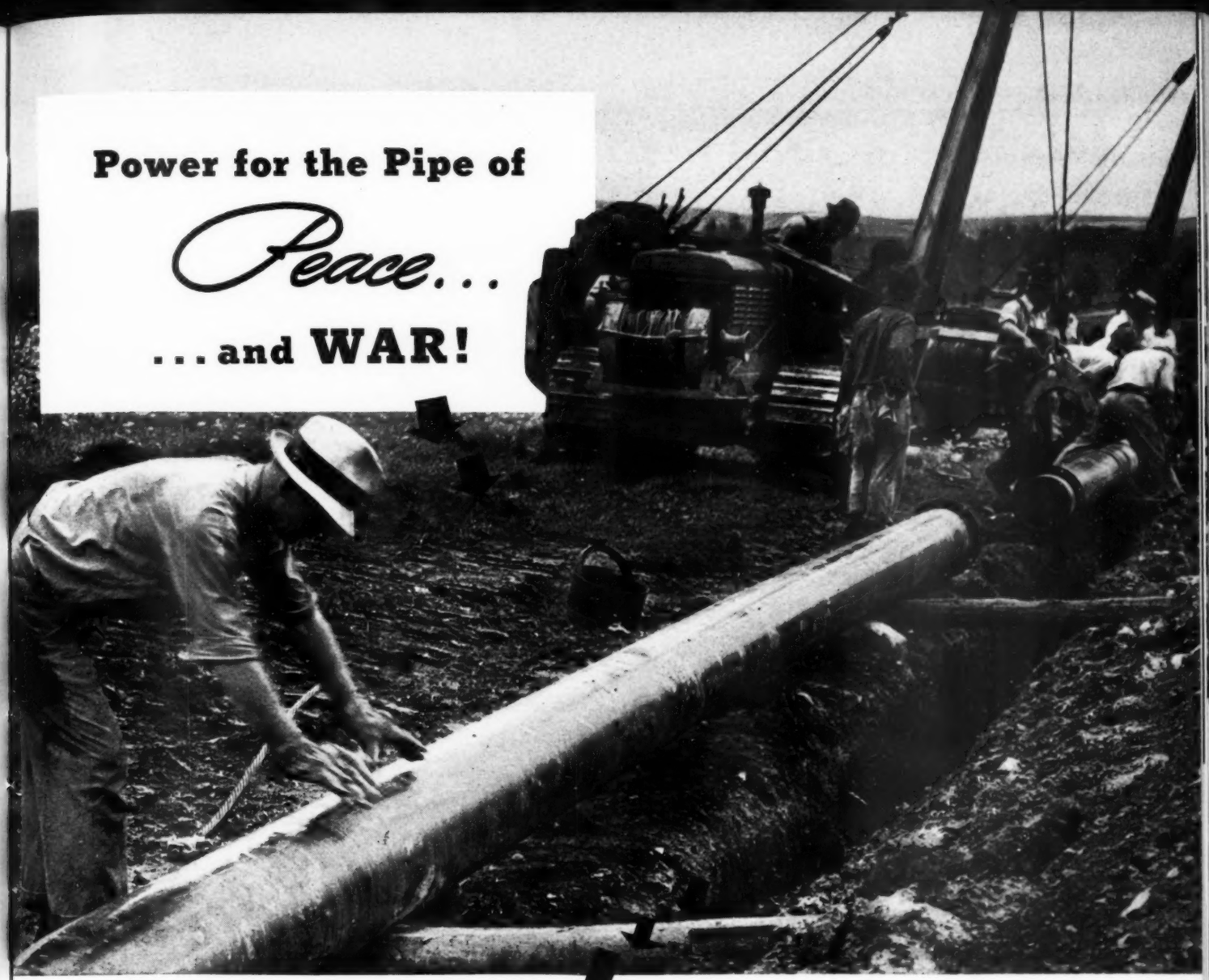
SURWEL	Clinograph	Magnetic Directional Tool Orientation
Syfo	Clinograph	Polar Core Orientation
E-C	Inclinometer	K-K Whipstock
	H-K	Inclinometer

Houston, Texas
Lubbock, Texas
Odessa, Texas
Corpus Christi, Texas

HEADQUARTERS FOR WELL SURVEYS

Fort Worth, Texas
Long Beach, California
Bakersfield, California
Oklahoma City, Oklahoma
Lafayette, Louisiana

SPERRY-SUN WELL SURVEYING CO.
1608 Walnut Street, Philadelphia, Pa.



with De La Vergne Diesel Engines

Since 1907 De La Vergne Diesel engines have powered many of the nation's vital oil pipe lines and have proven their dependability. Today, De La Vergne Diesels maintain the flow through many of the 120,000 miles of trunk and gathering lines scattered throughout the United States.

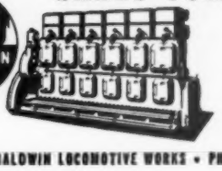
Working side by side with the oil companies, De La Vergne engineers have developed economical engines which provide dependable power for any pipe line job. De La Vergne Diesels are built in sizes ranging from 200 bhp to 1,500 bhp.

With many long trunk lines just completed, distance is no longer a problem in the transportation of oil. Dependable power at pumping stations means a steady, constant flow, pulsing through the veins and arteries of the oil industry.

And De La Vergne Diesels mean dependable power.

BALDWIN
De La Vergne
SALES CORP.

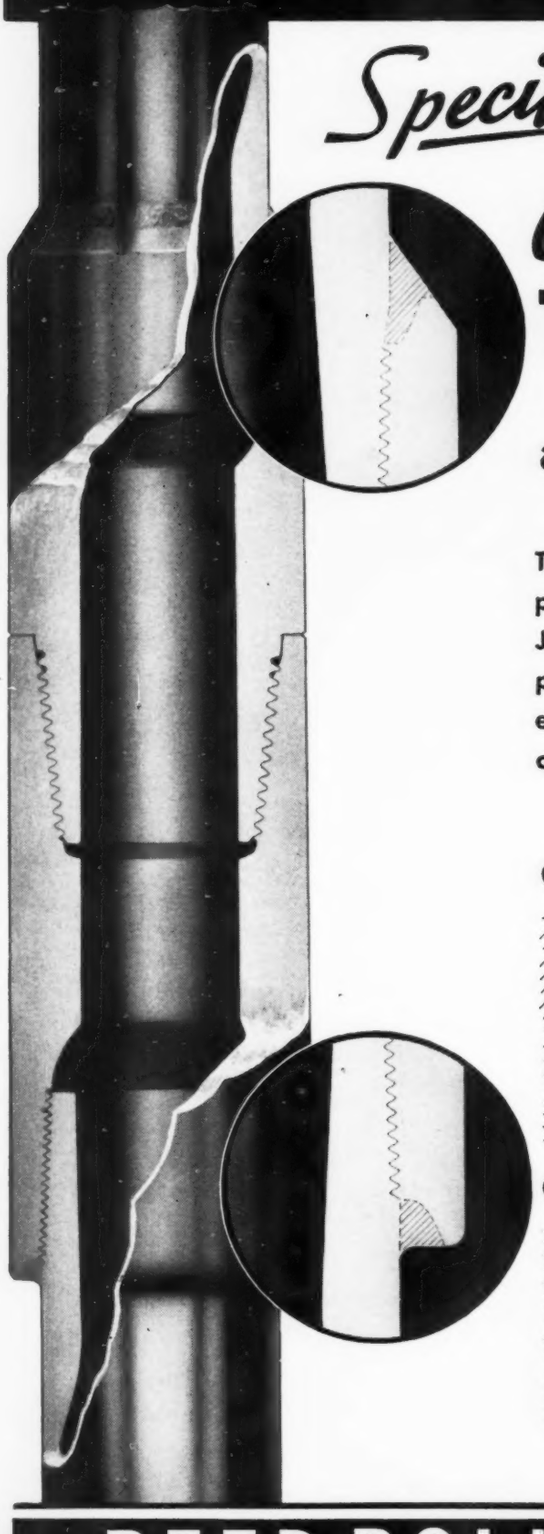
BLW
THE BALDWIN GROUP



SUBSIDIARY OF THE BALDWIN LOCOMOTIVE WORKS • PHILADELPHIA

BUILDERS OF DEPENDABLE ENGINES SINCE 1880

IF YOUR PREFERENCE IS A COUNTERBORE WELD TOOL JOINT.....



Specify **REED**

Counterbore Weld

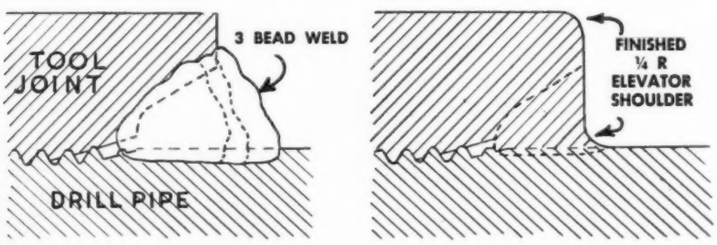
TOOL JOINTS

(SHAFFER PATENT No. 2,211,173)

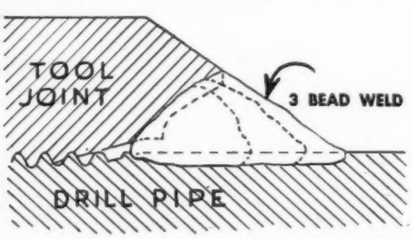
and be assured of Quality

The diagrams below show the three bead welding process used in welding Reed Counterbore Weld Tool Joints. This process normalizes each bead as it is applied and produces a *strong, sturdy weld* which assures effective distribution of stresses and maximum holding capacity.

COUNTERBORE WELD ON THE BOX END

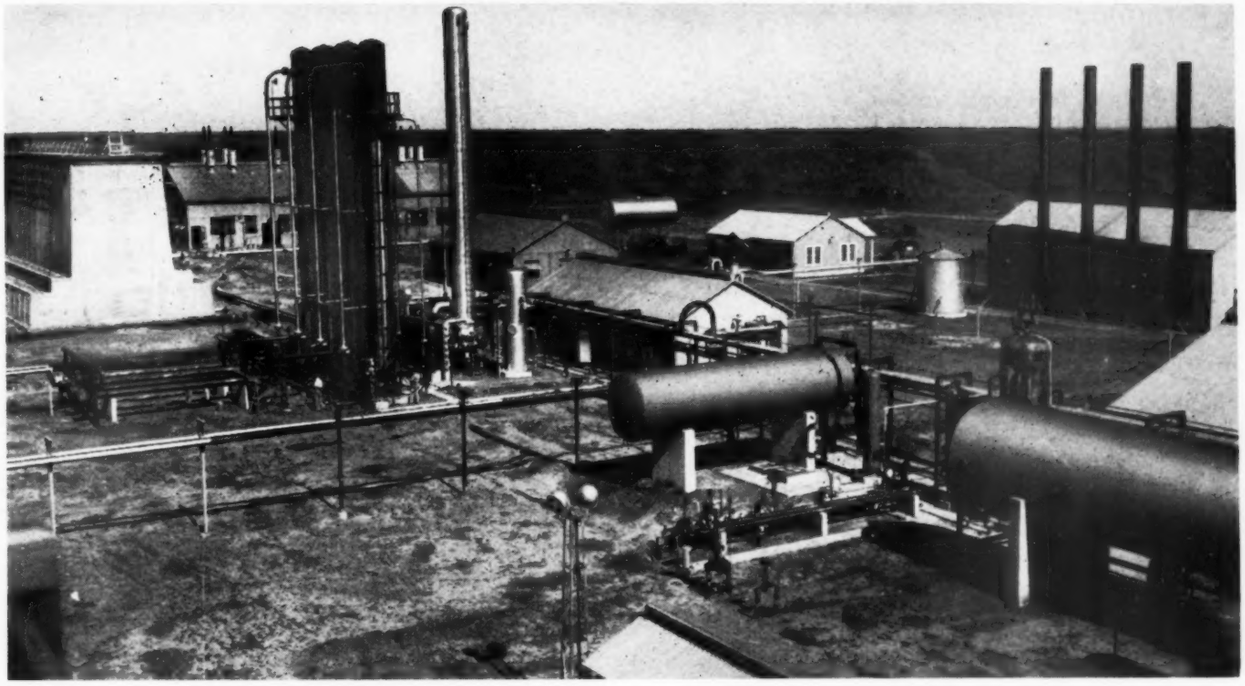


COUNTERBORE WELD ON THE PIN END



REED ROLLER BIT CO.

P. O. BOX 2119 HOUSTON, TEXAS



Hats off!! to

The CHICAGO CORPORATION

on completion of the large addition to the WARDNER plant. We are proud of our part in this work, which covers:

1st. *The Original Plant.* This was the first large Distillate Recovery and Pressure Maintenance Plant in the Industry.

2nd. *Changes and Additions.* These doubled the capacity of the Plant to 120 mm/cf per day, and converted it to the Absorption Process.

All of the work was done by us on a Turn-key basis, including design, furnishing all materials, fabrication of equipment in our own shops and field installation with our own construction forces.

Our ability to handle all phases of projects speeds completion and assures efficient, economical installations.

PARKHILL-WADE
1625 SOUTH ALAMEDA STREET
LOS ANGELES CALIFORNIA

- ***Distillate Recovery Plants***
- ***Gas Dehydration Plants***
- ***Compressor Stations***
- ***Natural Gasoline Plants***
- ***Stabilization Plants***

AFFILIATED WITH

THE STEARNS-ROGER MANUFACTURING CO.

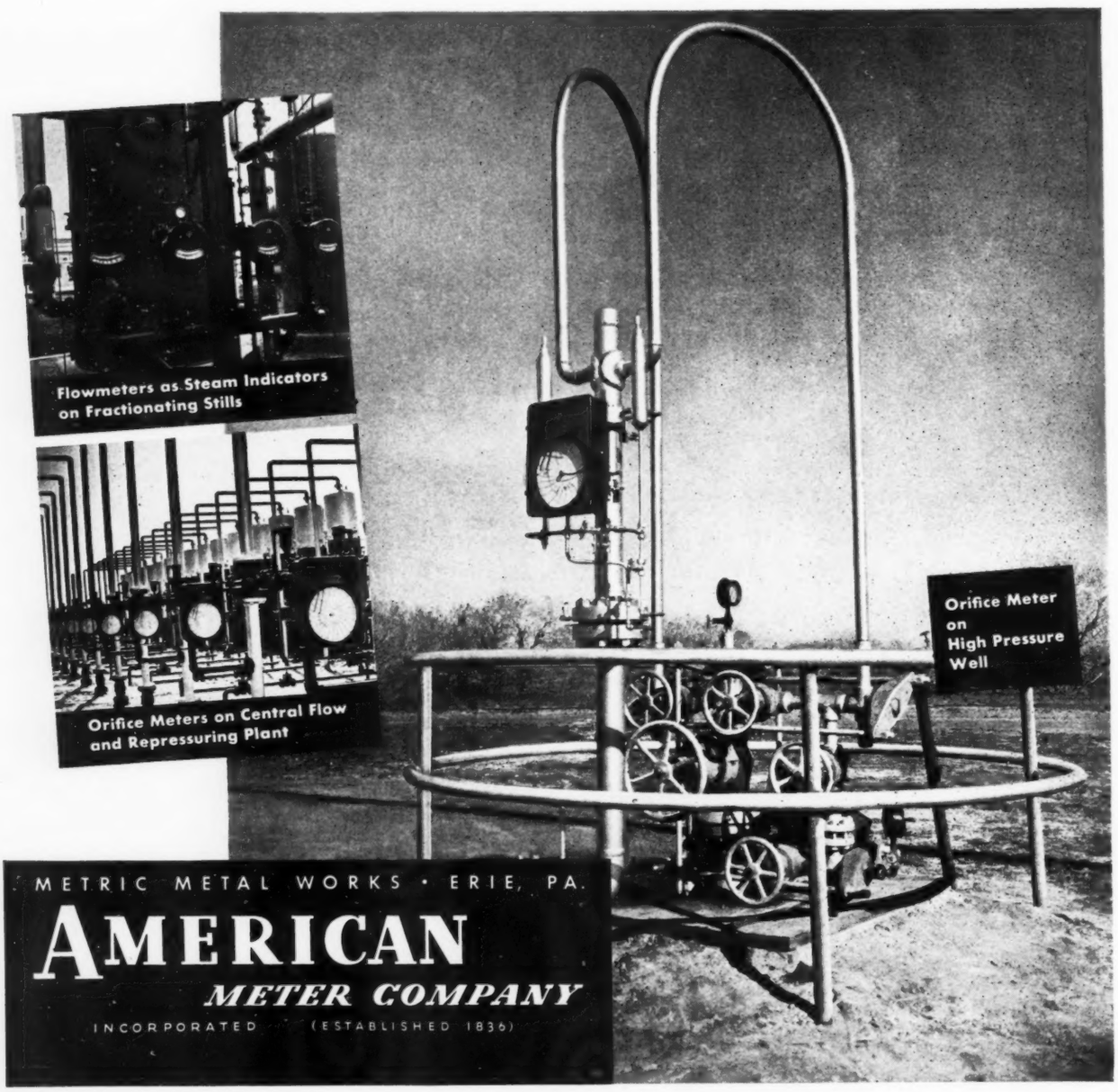
1720 CALIFORNIA STREET • DENVER, COLO.

The key *to successful* repressuring

The modern way of oil and gas men is to drag even the "squeal" out of producer and reserve wells! And it works — when plant and field conditions and equipment conform strictly to the right engineering set-up.

Talk with the engineers and maintenance men. Learn why METRIC-AMERICAN Orifice Meters and Flow-meters are specified for so many of these ticklish jobs—where to be inaccurate or slipshod or fragile may put a dent in profits!

NOTE: Construction and design features of these dependable instruments are detailed in American Meter Company's engineering bulletins which will be mailed you upon request.


Flowmeters as Steam Indicators on Fractionating Stills
Orifice Meters on Central Flow and Repressuring Plant
Orifice Meter on High Pressure Well

METRIC METAL WORKS • ERIE, PA.

AMERICAN METER COMPANY

INCORPORATED (ESTABLISHED 1836)

PETROLEUM ENGINEER EDITION

BAASH ROSS News

A BULLETIN COVERING NEWS OF EQUIPMENT AND OPERATIONS IN THE PETROLEUM INDUSTRY

NEW! "UNITIZED" BLOCK ASSEMBLIES SAVE VALUABLE DERRICK SPACE

Compact, Rugged, This B-R Development Adds Extra Feet to Portable Rigs

A troublesome drawback in the use of slim-hole drilling rigs, portable pulling outfits and similar equipment is the limited working height of the derrick. This reduced working clearance in many cases prevents the use of longer, faster-to-handle pipe lengths . . . and slows down all operations because of the constant danger of running into the crown.

But now you can add extra feet of usable working height to your rigs . . . extra feet of space that will enable you to handle longer pipe lengths—to work faster without risk of pulling into the crown . . . by using one of the new Baash-Ross developments—BAASH-ROSS UNITIZED BLOCK ASSEMBLIES!

Not only are these Unitized Blocks far more compact than conventional types, but they are also more *versatile*. Using the same Block unit, you have a choice of either a Hook Assembly or Link-Adapter Assembly—whichever best meets your requirements. These assemblies are interchangeable by simply pulling the coupling pin and replacing one type assembly with the other. Thus, should you buy say the Hook Assembly to meet your present requirements and later find that a shift in type of operations makes the Link Adapter Assembly more practical, you can change from one to the other *without the expense of replacing the Block!*

NINE BLOCK SIZES

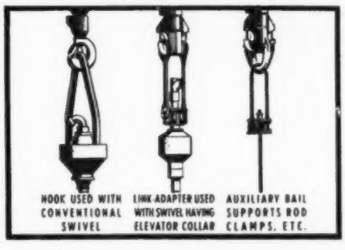
The Block itself is unusually husky and compact and is available in one, two, or three-sheave types, each with a choice of 20", 24", or 30" diameter sheaves, giving a selection of *nine* different block sizes to exactly fit your requirements.

Rated capacities are 30, 65 and 100 tons, with a 3 to 1 safety factor based on the yield point of the material. That's ample strength to handle just about any drilling job you can drum up for a slim-hole outfit—and is ample, also, for practically all types of production work!

WITH UNITIZED SPRING-LOADED HOOK

Wherever the conventional Hook connection is desired between the Block and rotary swivel or elevator links, the assembly with the spring-loaded Hook as shown in figure 1 is the one to use. The Hook itself is free-swiveling . . . and is mounted on ball thrust bearings easily lubricated through an outside grease connection. When no swiveling is desired, the Hook can be locked in any one of *four* different positions by simply throwing a built-in locking pin!

But that's not all. Note, in the inset, the special automatic latch for locking the Hook in closed position—an important safety point, and a big convenience. When open, this latch acts as a guide for picking up swivel and elevator links, then *automatically* snaps shut as the links drop into the curve of the Hook. The latch *can't* open under load, insuring safety in rough work!


HOOK USED WITH CONVENTIONAL SWIVEL
LINK ADAPTER USED WITH SWIVEL HAVING ELEVATOR COLLAR
AUXILIARY BAIL SUPPORTS ROD CLAMPS, ETC.

WITH SPRING-LOADED LINK ADAPTER

▶ **Where maximum space-saving compactness** is desired, you get it with the B-R Block assembled with spring loaded Link Adapter, as shown in figure 2. Here, the elevator links hook directly into ears provided on each side of the adapter where they can be easily locked in place by bolts. By equipping the swivel with an elevator collar, the same elevators that lift the pipe serve also to support the swivel, thus eliminating the extra space otherwise occupied by a hook.

This Link-Adapter unit has the same free-swiveling feature as the Hook Assembly and can be locked in any one of four different positions by simply throwing a built-in lock. The Adapter can also be equipped with a bottom bail as shown to facilitate auxiliary operations, such as supporting tubing elevators, etc.

CHECK THESE HEAVY-DUTY FEATURES

Now, how about construction? Here's an inside look that will show you how this Block is *engineered* right up to the second for the heaviest, hardest usage.

First, it has fewer parts than most types and is as tough and compact as a welter weight. *That means money saved on maintenance and replacement.* No need to point out how vital that is today! Side plates are solid one-piece rib-reinforced steel castings, through which pass center pin, coupling pin and top pin to make the unit rigid and twist-proof top to bottom. Individual sheave bearings are of the heavy-duty roller type with separate grease fittings and ducts to insure positive lubrication to *each* bearing. Unique cage design of the bearings permits a greater number of rollers to be used than ordinarily possible, *increasing load capacity without increasing bulk.* Guards protect each sheave and can be quickly removed for easy threading of the line, saving crew time when rigging up and dismantling.

Streamlined

All bolts, pins, nuts, grease fittings, etc., are completely streamlined into the side plates so that there are no projections anywhere to catch on *anything*—the derrick, workmen's clothing, or obstructions in the rig! This is one Block that's *completely* streamlined at every point for maximum operating safety.

Your Baash-Ross representative will be glad to go into the full details concerning these Unitized Block Assemblies . . . to explain the *many* other exclusive and advanced features which make these Blocks stand head and shoulders above the field for all your slim-hole drilling and portable well pulling operations. Plan to get in touch with him *today*—or write Baash-Ross direct!

ON THE LOOKOUT

THE SPECTROPHOTOMETER, *long an important tool in metallurgical and chemical laboratories, is now playing an increasingly important part in simplifying analysis work in the petroleum industry. Several majors are reported using it for rapid, accurate analysis of core and soil samples and of oil field waters. A new Spectrophotometer, recently announced, incorporates many important developments in Spectrophotometric design that particularly recommend it for such petroleum work.* **(No. 314)**

BAASH-ROSS

EVEN IN A DEPLETED FIELD, geologists state, over half the oil remains in the ground adhering as a film to the individual sand grains. It is the practice in some fields to inject water into the sands to "wash" this oil loose and drive it to the well bore. A recent report discloses that oil recovery by this method can be greatly increased simply by adding small amounts to chemicals known as "wetting agents" to the injected water. In one instance cited, substantial increases were obtained with as low as 0.1% concentration of wetting agent. **(No. 315)**

For additional information on these items, send on a post card or letterhead your name, address and key number of items that interest you.

Lower Lifting Costs

with NATIONAL UNIT PUMPERS

★ Lower your lifting cost with Pumpers that fit the loads and operating conditions. National's line of Unit Pumpers is so extensive that it is easy to select a Unit most efficient for the job.

BRIEF SPECIFICATIONS	TYPES FOR LIGHT TO MEDIUM SERVICE						TYPES FOR MEDIUM TO HEAVIEST SERVICE	
	TU24G-JD2TP	TU104-HD10TP	TU164G-HD16TP	TU & TUS 164G-HD16TB	TUS234-JD23TB	TUS304-HD30TB	TUS464-HD46TB	TU1604-HD160T
API Walking Beam Rating, Pounds	3200	6725	8900	8900	9125	12750	15100	32400
Max. Polished Rod Stroke, Inches	16	28	34	34	42	48	54	120
Max. Counterweight Effect at Max. Polished Rod Stroke, Pounds	2476	5340	6873	4860	5600	8480	11040	27500
Peak Torque Rating at 20 SPM, Inch Pounds	6360	24300	40200	40200	57200	76500	113000	432500
Overall Gear Ratio	26.0	29.2	29.2	29.2	29.8	29.6	30.8	30.3
Well End Working Centers, Inches	24	42	51	51	63	72	81	180
Walking Beam Size and Weight, CB Section	6x12 lbs.	10x26 lbs.	12x36 lbs.	12x36 lbs.	14x42 lbs.	16x58 lbs.	18x70 lbs.	33x200 lbs.

DOMESTIC
EXECUTIVE OFFICES
PITTSBURGH, PENNA.
•
GENERAL SALES OFFICE
TOLEDO, OHIO
•
DIVISION OFFICES
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NATIONAL

THE NATIONAL SUPPLY COMPANY

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NEW YORK, N. Y. . . . U. S. A.
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LIMITED LIABILITY
•
PLOESTI, ROUMANIA
•
MARACAIBO, VENEZUELA

3rd Annual Pipe Line Number 1942

Portland-Montreal Pipe Line

The several pictures on this page were taken on the defense line popularly termed the Esso Pipe Line, extending from Portland, Maine, to Montreal, Quebec. The interior and exterior views of a pumping station were taken at South Portland. The four comfortable cottages shown in the lower left-hand corner of the page house employees at the Raymond, Maine, station. The photograph running diagonally through the page reveals the rugged-type country through which a considerable part of the line was laid.

AID NATIONAL DEFENSE

Save Steel

Use SOMASTIC

REG. U. S. PAT. OFF.

PIPE COATING

On New Pipe Lines . . .

SOMASTIC Pipe Coating, by reason of its absolute protection, permits the use of lighter-weight pipe.

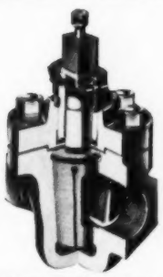
On Existing Pipe Lines . . .

SOMASTIC Pipe Coating conserves steel by furnishing *permanent protection* against loss from corrosion.

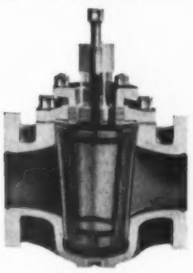
SOMASTIC Pipe Coating *is being used on Defense Pipe Line Projects*

KEEP UPKEEP DOWN

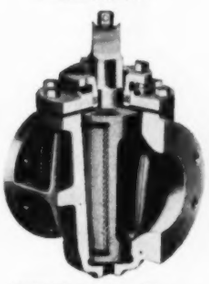
with these ALL-PURPOSE VALVES



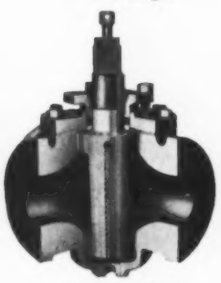
Screwed Gland Type
4" and Smaller



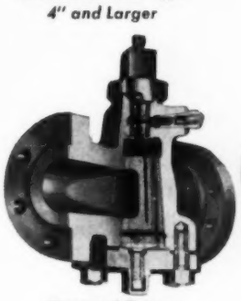
Bolted Gland Type
4" and Larger



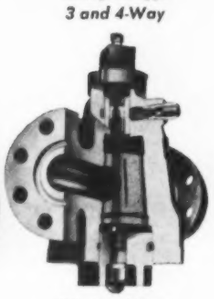
EMCO-Nordstrom Type
4" and Larger



Multiport Type
3 and 4-Way



Hypreseal Type
Flanged Bottom
Rectangular Opening



Hypreseal Type
Screwed Bottom
Round Opening

Descriptive Bulletin upon request.

DYNAMIC PERFECTION IN NORDSTROMS

All valves embody a dynamic principle. But dynamic *perfection* is a rare achievement. Its accomplishment in Nordstrom Valves marks one of the milestones in engineering progress. Comprised essentially of a plug and body, Nordstroms utilize the simplest dynamic principle—that of turning a movable member within a sealed chamber. Nordstroms present the perfect application of the principle. With "Sealdport" lubrication and numerous other engineering advancements, Nordstorm Valves offer a cut-off control which is positive and as complete as though the line was sealed with a welded blank or blind. Incidentally, the practice of using blanks or blinds in connection with valves is totally unnecessary where Nordstroms are installed. The diversified use of Nordstroms on gas, oil, mud and chemical lines with working pressures, in some instances, running to 7500 lbs. and temperatures up to 950° F., is indicative of their perfection.

Nordstrom LUBRICATED VALVES

Sealdport Lubrication

MERCO NORDSTROM VALVE COMPANY—*a Subsidiary of* Pittsburgh Equitable Meter Company

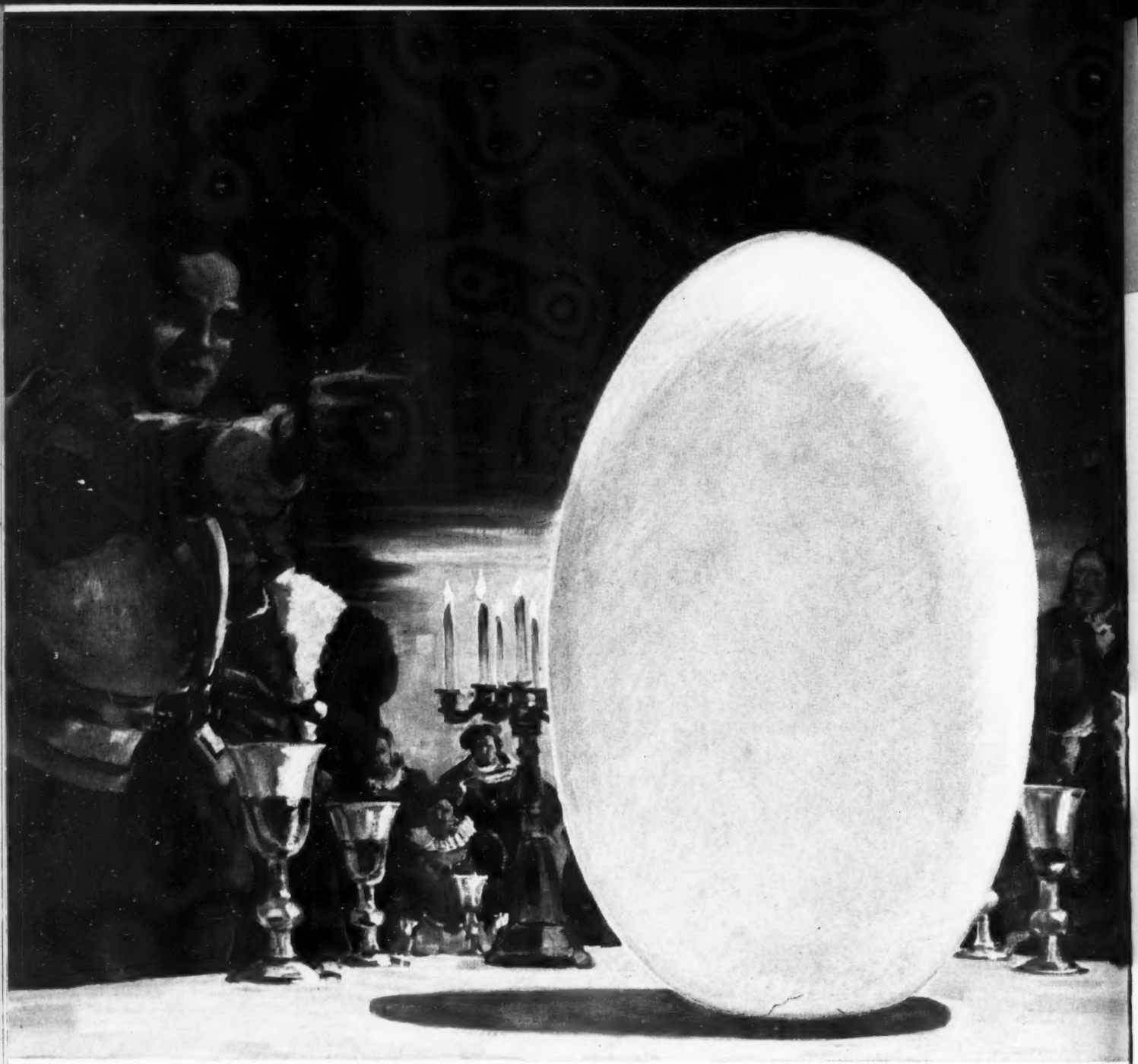
WORLD'S LARGEST MANUFACTURERS OF LUBRICATED PLUG VALVES; GASOLINE, OIL & GREASE METERS

Main Offices: 400 Lexington Ave., Pittsburgh, Penna.

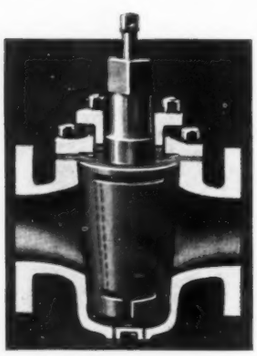
BRANCHES: New York City, Buffalo, Philadelphia, Columbia, Memphis, Chicago, Kansas City, Des Moines, Tulsa, Houston, Los Angeles, Oakland.

CANADIAN Licensees: Peacock Bros., Ltd., Montreal. • *EUROPEAN Licensees:* Audley Engineering Co., Ltd, Newport, Shropshire, England

PRODUCTS: Nordstrom Lubricated Valves; Air, Curb and Meter Cocks • Nordstrom Valve Lubricants • EMCO Gas Meters • EMCO-McGaughy Integrators EMCO Regulators • Pittsburgh Meters for Gasoline, Grease, Oil, Water and other Liquids • Raybould Couplings • Stupakoff Bottom Hole Gauges



...it can't be done! Stand an egg on end? *Preposterous!* But Columbus was unperturbed. He deftly brought the egg down on the table, cracking it slightly at the bottom. The skeptics were amazed, for *there it stood.* ¶ Instinctively, it seems, Nordstrom Valve engineers have the knack of doing the *impossible.* Miracle valve accomplishments have been attained again and again as a result of Nordstrom ingenuity and initiative. *For instance:* Nordstrom pioneered the first successful lubricated plug valve. Nordstrom has built the largest plug valves, (30″). Nordstrom has developed the only types of valves with lubricants capable of operating at temperatures of 950° F. Nordstrom brought forth Hypreseal, the only plug valve that can take test pressures up to 15,000 lbs. per square inch. Nordstrom introduced new brittle-resistant alloys for temperatures of -150°. And again Nordstrom has cast precedent aside by *Merchroming* valve plugs and bodies with a continuous hard-facing for use in high temperature service and for corrosive and erosive conditions. The "toughest jobs" eventually come to Nordstrom; proof enough these valves meet *all* your needs.



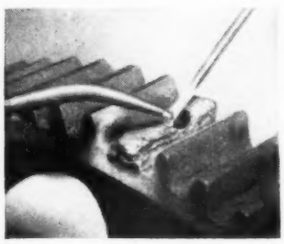
When it can't be done* NORDSTROM *does it!

To make the most of Available Parts and Materials

Take full advantage of these Oxy-Acetylene Processes

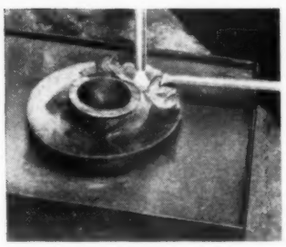
FULL utilization of all available metal parts and materials is now essential. Every metal part that *can* be *reclaimed* or *repaired* for re-use must be. Every part which can be *protected* from wear so as to prolong its life, should be so protected. Wherever a more readily available base metal can be *substituted* for special steels, that substitution should be made.

Outlined here are three Linde methods which can help you to do these things.



Oxy-Acetylene Welding

when metal parts break or wear, investigate the advantages of having them reclaimed by means of oxy-acetylene welding. Bronze-welding, for example, makes it possible to *quickly* repair broken gears, castings, forgings, and many other types of equipment with welds as strong as the base metal. Even dissimilar metals can be strongly joined by this method. An additional use of bronze-welding which has great value is the reclamation of *worn* parts and bearing surfaces. *Send for the booklet, "Instruction Outline For Bronze Welding." A copy will be sent without charge.*



Hard-Facing

Many problems of parts replacement can be prevented by applying Haynes Stellite hard-facing materials to parts subjected to severe abrasion, heat, or corrosion—*before wear occurs.* Then when such parts do become worn from long, hard use, they usually can be rebuilt again and again to provide additional trouble-free service. *To help you to use this method of conserving metals and making parts last longer, a copy of the booklet, "Steel Hard-Facing Procedure," will be sent upon request, without charge.*

Where You Can Have This Work Done

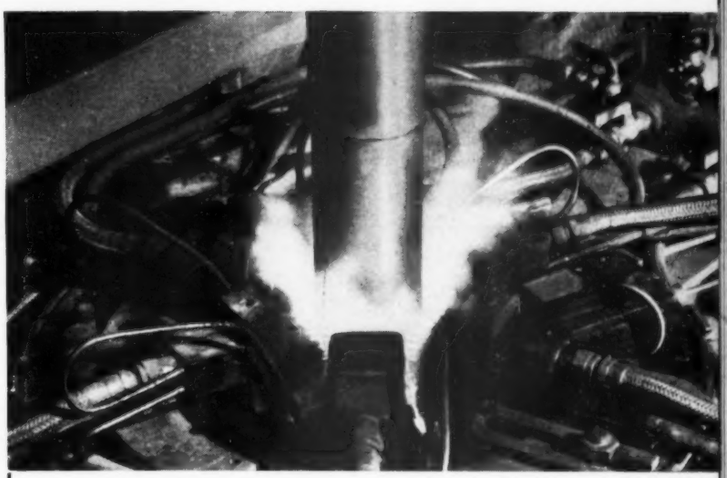
If you are not equipped to do your own flame-hardening, welding, hard-facing, or cutting—utilize the facilities of one of the custom shops in your area. By writing any Linde office you can obtain the name and address of dependable shops which are qualified to serve you.

The Linde Air Products Company

Unit of Union Carbide and Carbon Corporation

30 East 42nd Street, New York UCC Offices in Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto



Oxy-Acetylene Flame-Hardening

Oxy-acetylene flame-hardening imparts a hard case to wearing parts to make them last longer. This is done by heating the area to be hardened with oxy-acetylene flames, and then quenching with water or oil. Commonly used steels and high-tensile cast iron can be flame-hardened successfully. Small areas can be "spot" hardened with a welding blowpipe. Larger areas are usually hardened with mechanized equipment by the "progressive" or "spinning" methods, or—as shown above—by a combination of the two.

These Are Its Advantages

In many cases, oxy-acetylene flame-hardening is not only the best method, but is the *only* practical method of providing a wear-resistant surface on steel and iron parts. Eight advantages of this process are:

1. Parts of any size or shape can be hardened
2. Readily available base metals can often be used in place of special steels
3. The toughness of the core is unaffected
4. There is no appreciable distortion
5. Chemical composition of the metal is unchanged
6. Penetration can be closely controlled
7. The hardened area does not tend to spall off
8. Worn steel parts can be rebuilt by welding and the surface then protected against future wear by flame-hardening.

Typical Parts Being Hardened

Some of the many industrial and petroleum equipment parts which are being flame-hardened successfully are:

Hot oil plungers	Sprockets
Pump rods	Gears
Tool joints	Catheads
Tool joint subs	Mud Swivels
Pump liners	Sheaves

Send for the booklet, "Fundamentals of Flame-Hardening." It will tell you more about this modern method of preventing wear.

The words "Linde," "Prest-O-Lite," "Union," "Oxweld," and "Haynes Stellite" are trade-marks of Units of Union Carbide and Carbon Corporation.

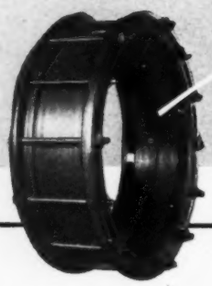
LINDE OXYGEN . . . PREST-O-LITE ACETYLENE . . . UNION CARBIDE . . . OXWELD APPARATUS AND SUPPLIES

How To Lay Lines

Fast

✓ **DRESSER COUPLINGS GIVE GREATER SPEED**

Advantage No. 4 of 12 Proved Advantages Listed in Box Below



CHECK THESE 12 PROVED ADVANTAGES THAT ONLY DRESSERS GIVE YOU

1. Dresser Couplings eliminate all uncertainty in joint-making.
2. Dresser Couplings permit use of local, untrained labor.
3. Dresser Couplings provide the only time-proved method of absorbing expansion and contraction.
4. ✓ Dresser Couplings give greater speed.
5. Dresser Couplings simplify both pipe and joint specifications.
6. Dresser Couplings can be installed regardless of weather, wind, or rain conditions.
7. Dresser Couplings eliminate "fussy" operations.
8. Dresser Couplings permit pipe deflection for curves and grades with straight pipe.
9. Dresser Couplings reduce cost of supervision and inspection.
10. Dresser Couplings cut maintenance costs.
11. Dresser Couplings are fool-proof, strong, *permanently* tight.
12. Dresser Couplings eliminate health and fire hazards.

Speed has always been a factor in pipe-line construction. *Today,* it is more important than ever. That is why pipe-line men everywhere are turning to Dresser Couplings.

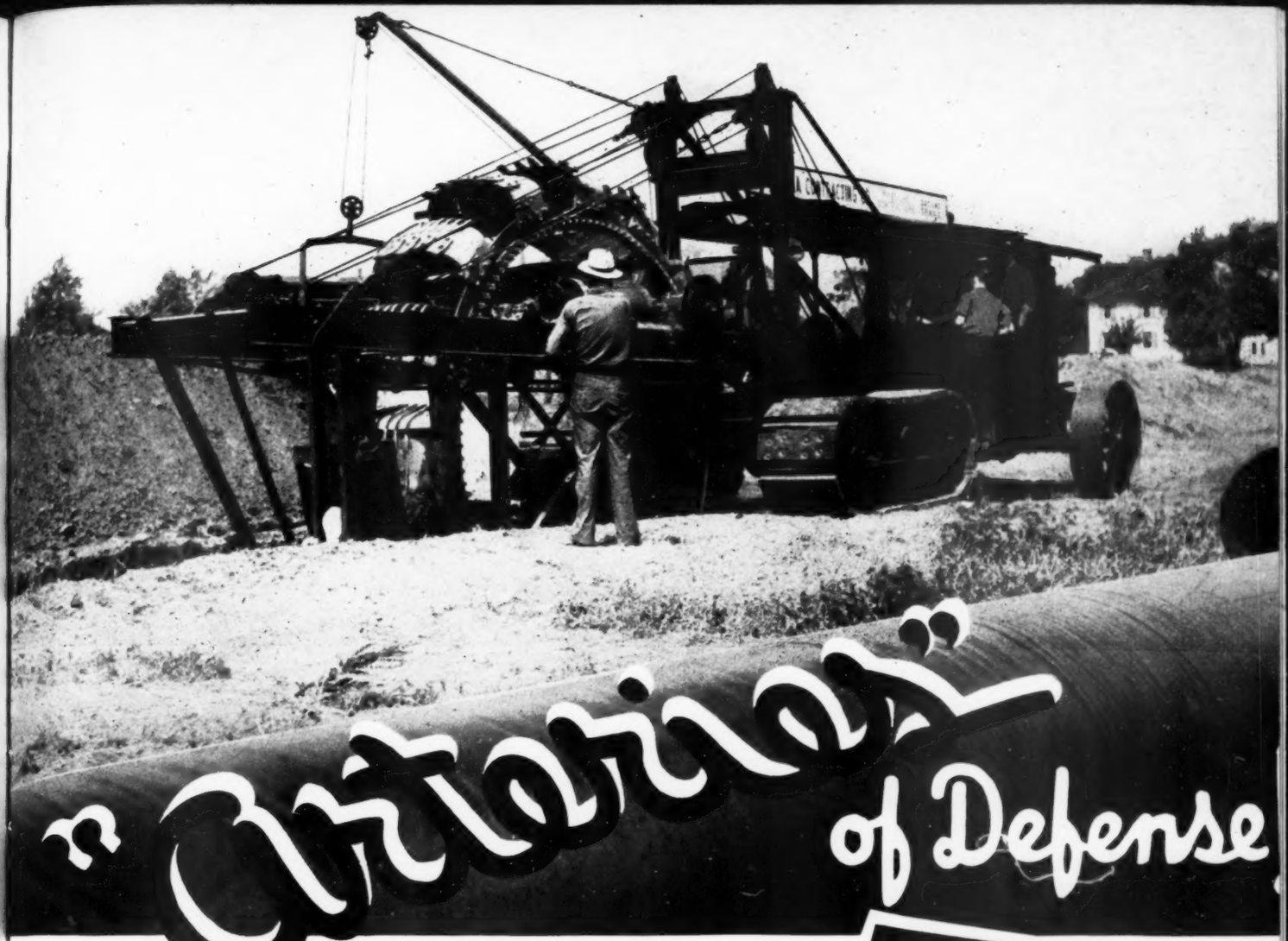
For with Dressers, pipe-joining moves forward like *clock-work.* Everything is coordinated, uniform, *standard.* Every joint is the same, regardless of wind, weather, or terrain conditions. Every joint is permanently tight.

You use local, unskilled labor. Your crews are small, compact, easily supervised, their work readily inspected. The only "machinery" needed is a wrench. Pipe can be safely joined above the ditch. No harmful lowering stresses. No bell-holes. Everything contributes to simplicity and speed. *Specify Dressers.* Save time and dollars during construction—safeguard your line after construction.

Dresser Manufacturing Company • Bradford, Pa.

DRESSER PIPE COUPLINGS

SAVE LABOR • SAVE TIME • SAVE WORRY—WITH DRESSERS



"Arteries" of Defense

Our pipelines are the arteries through which flows the lifeblood of the nation, without which we would perish. A steady stream from oil fields to refineries.

Crude for lubricants for a million machines; diesel fuel for the merchant marine, power plants, construction equipment; bitumens for roads, airports, chemi-rubber, paints; oil to make steam and electricity to turn the wheels.

Gasoline to "keep 'em flying" and for tanks, jeeps, trucks and seacraft.

Gas for the forges, the heat-treating furnaces, and a thousand essential processes.

Pulsating through 150,000 miles of pipelines to speed National Defense.

Buckeye Pipeline Trenchers are working — night and day, in many cases — to make more trench for more pipelines which, with what we have, will make our nation *invulnerable*.

BUCKEYE TRACTION DITCHER CO.
FINDLAY, OHIO

Models 32, 48 (shown) and **49** for transmission main lines.

Models 11 and **12** for gasoline, gathering lines, gas service pipe trench.

Built by Buckeye

Convertible Shovels

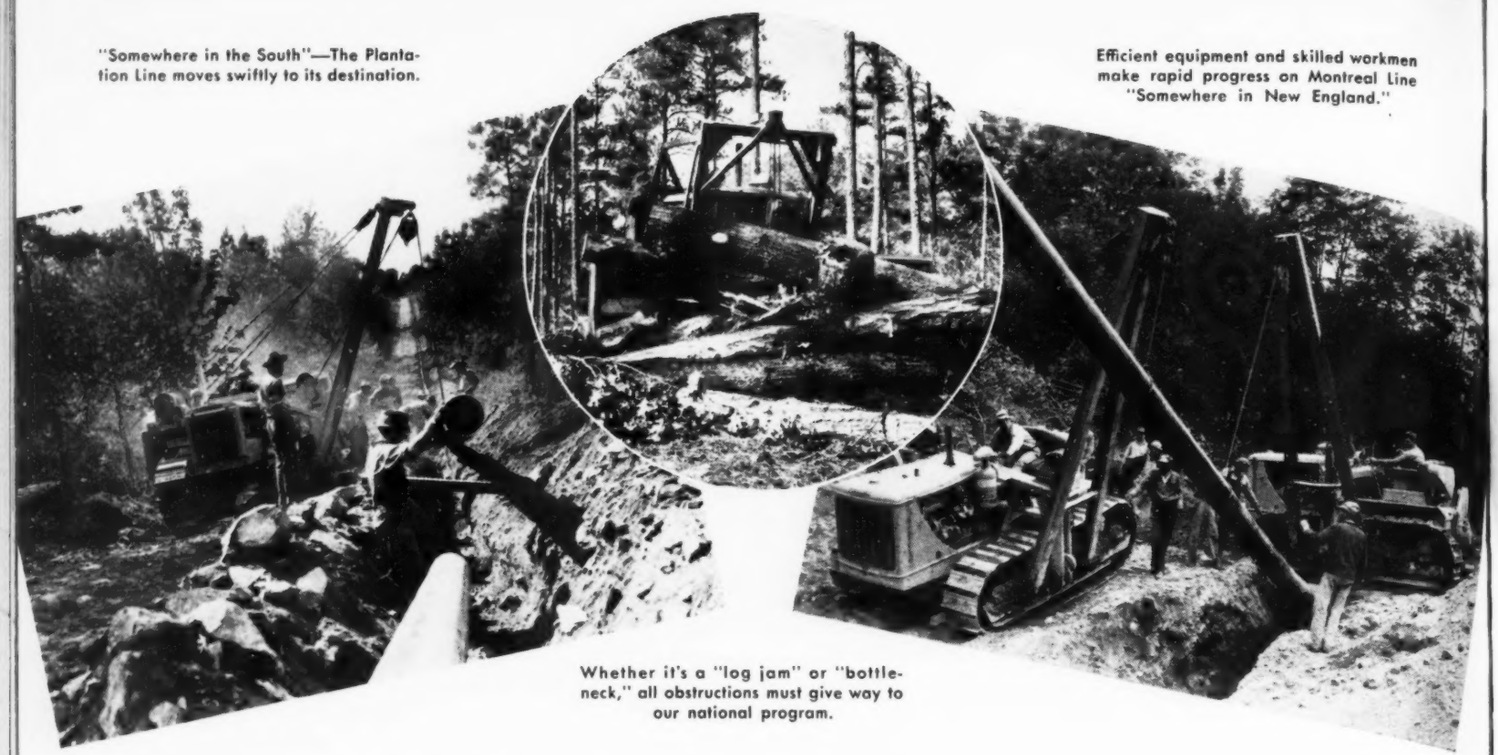
Trenchers

Tractor Equipment

R-B Finegraders

Road Wideners

Spreaders



"Somewhere in the South"—The Plantation Line moves swiftly to its destination.

Efficient equipment and skilled workmen make rapid progress on Montreal Line "Somewhere in New England."

Whether it's a "log jam" or "bottleneck," all obstructions must give way to our national program.

LIFELINES.... *of National Defense*

★ Bombers and tanks and guns and battleships alone cannot win the war. These depend upon high octane motor fuel and proper lubrication . . . both for their manufacture in American and Canadian factories and their successful operation on land and sea and in the sky. Pipelines . . . great steel arteries through which this vital lifeblood of the Allies' mechanized war machine must flow . . . are vitally necessary NOW.

★ Williams Brothers is proud to play an important part in the construction of two projects so essential to our war efforts. On the Plantation Pipe Line from Baton Rouge, Louisiana, to Greenville, North Carolina, Williams Brothers is building 584 miles of 10-inch main lines and 8-inch lateral lines. On the Montreal Pipe Line from Portland, Maine, to Montreal, Quebec, we built 156 miles of 12¾-inch line and all eight pumping stations.

★ There are reasons why Williams Brothers and affiliates have been entrusted to build nearly 20,000 miles of major pipe line on two continents, from Canada to South America: a generation of experience, an efficient staff of engineers, and a force of skilled workmen combine to enable this organization to offer a highly specialized service.

WILLIAMS BROTHERS CORP.

GENERAL CONTRACTORS **ENGINEERS**

Oil . . . Gas . . . Gasoline . . . Water Pipe Lines and Pump Stations

CHICAGO **TULSA** **ATLANTA** **HOUSTON**

Today's Keynote

Hard work, confidence and understanding . . . the keynote for today! *Work* to us means unceasing effort by all to provide every needed essential to the Nation's war effort and to divert every remaining effort toward maintaining our own production because of its essential character in both civilian morale and the subsistence of our armed forces.

But hard work alone is not sufficient. It must be guided by confidence and understanding . . . confidence in our future and understanding of necessary war-time restrictions, and this calls for clear-headed thinking by all . . . the user . . . the distributor . . . the manufacturer. All for the single urgent cause of Victory . . . an emergency we dare not overlook . . . an economic situation that revolves around shortages of skill and materials.

Our suggested keynote for today does not sum up as a hard, fast rule. Each of us has individual problems to counter . . . and each must find a personal solution. But basically, why shouldn't we all apply a general policy of hard work plus confidence and understanding in our daily dealings?

At Kerotest we are united in an effort to lend every possible facility to National Victory . . . we are strong, too, in our belief that you, the Oil Industry, play an essential part in this nation's concerted action and *deserve* all available assistance that Kerotest can lend.

Kerotest's part must and will be in the form of continuous production on as large a scale as possible . . . and deliveries as promptly as possible under war-time priority restrictions.

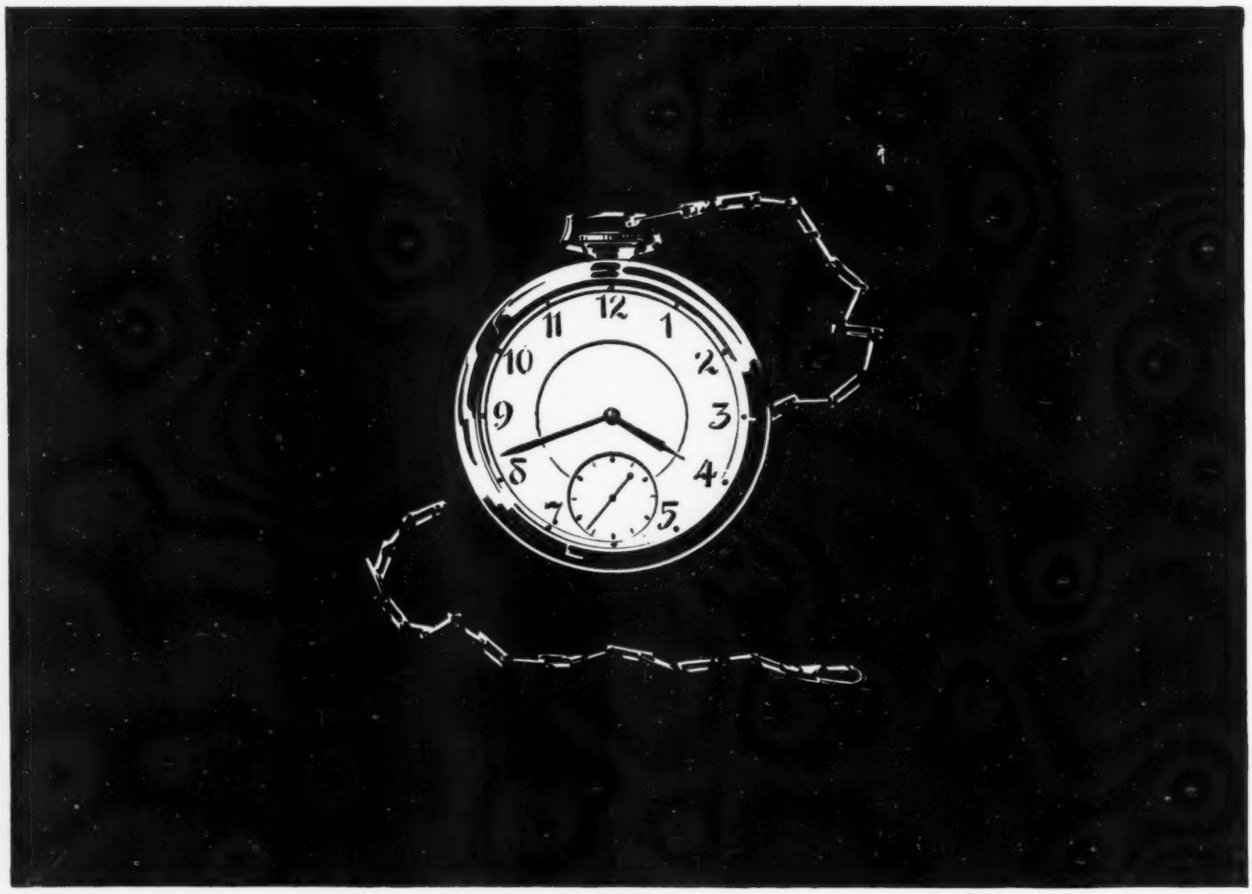
KEROTEST MANUFACTURING COMPANY

PITTSBURGH · PENNSYLVANIA

J. C. Stackhouse

General Sales Manager

KEROTEST



BEAUTIFUL—*BUT WHAT KEEPS IT "ON TIME"?*

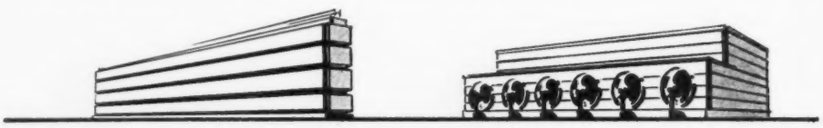
The real hazard in the purchase of a cooling tower is to consider an apparent saving in first cost as permanent economy. In Fluor Cooling Towers there is no temptation to save at the outset—but intelligent determination to save in the long run. Like a fine watch, everything is calculated—design, dimensions, materials.

Fluor Cooling Towers are higher in first cost; yet in terms of effective performance and retention of rated thermal efficiency over the longest period of years, their cost is actually less. As you would open a fine watch to judge its value, look inside a Fluor Cooling Tower. Observe that all posts are oversize—that there are more columns, braces and ties per tower—that critical points are bolted, not nailed. Fluor decks are permanently positioned; they will not get out of place nor sag. Thus thermal efficiency is assured for the life of the tower because water distribution is always uniform. These are but a few of the features through which Fluor builds added years of service into each tower—right at the start!

Whatever your problem, Fluor builds a type of tower to solve it. If space is not a limiting factor, we recommend Fluor Atmospheric Cooling Towers; for restricted areas and minimum wind conditions, Fluor Induced Draft or Forced Draft Cooling Towers.

When considering the installation of a cooling tower, remember this: A good basic rule to follow is—*Be Sure With Fluor!* Take the first step now—*write for literature!*

ATMOSPHERIC AERATOR TYPE—MECHANICAL DRAFT TYPES



SINCE fc 1890

FLUOR COOLING TOWERS

THE FLUOR CORPORATION LTD.

Main Office and Plant: 2500 South Atlantic Blvd., Los Angeles, California

New York City • Pittsburgh, Pennsylvania • Kansas City, Missouri • Houston, Texas

IT ALWAYS WAS GOOD BUSINESS TO TAKE CARE OF YOUR EQUIPMENT—NOW IT'S PATRIOTIC, TOO
AND REMEMBER—GOOD TOOLS LAST LONGER
SPANG

SAVE COATING - SAVE TIME - AND GET A BETTER JOB...

The Wailes Dove-Hermiston machine being used on 50 miles of 26" O.D. natural gas pipe for the Natural Gas Pipeline Company of America.

...with the ***NEW***

WAILES DOVE-HERMISTON LINE TRAVELING, PIPE COATING AND WRAPPING MACHINE

WAILES DOVE-HERMISTON CORPORATION announces a new Line Traveling, Pipe Coating and Wrapping Machine which incorporates many new and radical improvements developed after years of research.

A sump tank underneath the machine contains the hot Bitumastic Enamel which is pumped into an annular ring surrounding the pipe. The Enamel, emitted under pressure from holes in the inner face of the ring, floods the pipe uniformly on all surfaces. Supplementary orifices apply an extra coating to a large portion of the bottom of the pipe.

The machine is compact and sturdy, and is self-propelled on the pipe – uphill and downhill and around bends – as fast as the pipe can be laid.

The principal advantages of the machine are:

- **The coating thickness is uniform on all surfaces of the pipe.**
- **The minimum amount of coating material is required for any specified thickness.**
- **Double coating the bottom assures full thickness where the pipe is exposed to corrosive soil waters in the bottom of the ditch.**
- **Holidays are practically non-existent, thereby reducing touch-up expense to a minimum.**
- **Vital parts of the machine are kept at a temperature of about 600° F. This enables the machine to start coating operations without delay.**
- **No moving parts are in contact with the pipe during or after the coating application. No defects due to scraping can occur in the coating under the wrapper.**
- **The machine is so sturdily constructed that delays from serious breakdowns are improbable.**

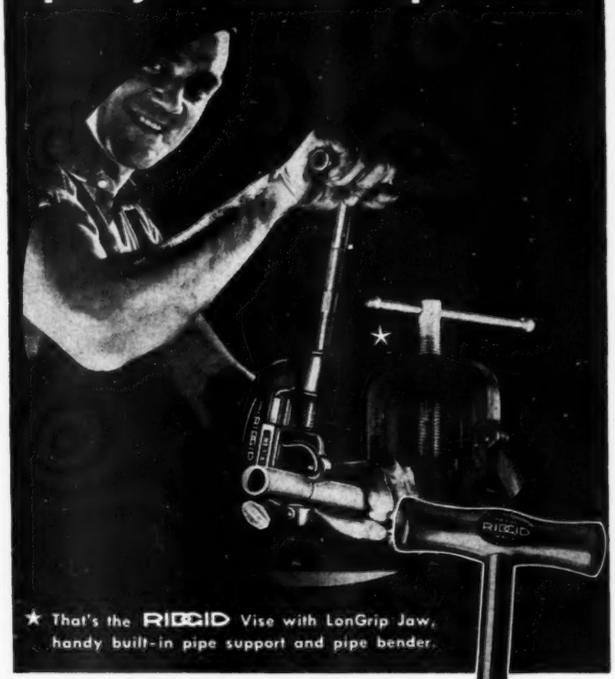
WAILES DOVE-HERMISTON CORPORATION

WESTFIELD NEW JERSEY

NEW YORK • PHILADELPHIA • CLEVELAND • CHICAGO • HOUSTON

TULSA • SAN FRANCISCO • LOS ANGELES • MIAMI

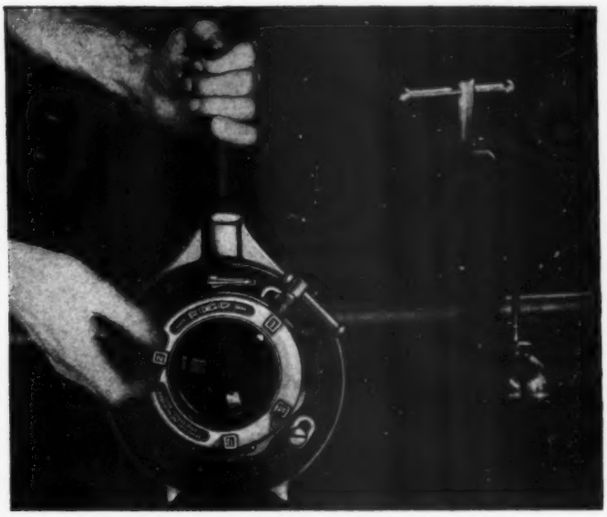
You Lick Delays with this Speedy RIDGID Pipe Cutter



★ That's the RIDGID Vise with LonGrip Jaw, handy built-in pipe support and pipe bender.

There's no time these days for slow tools — in construction, production or maintenance, no speed is good enough... Well, you cut *more* pipe with *less* effort with this RIDGID. Special thin cutting wheels, forged and assembled in solid hubs, roll easily and cleanly through any pipe, save reaming time. Heavy-duty malleable frames that stand overwork, always cut true. Made 3-wheel and 4-wheel (No. 42) for still speedier cutting. Four sizes, for pipe to 4". Don't tolerate even small delays—buy time-and-work-saver RIDGIDs at your Supply House.

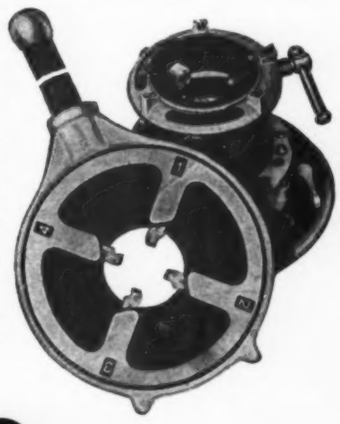
RIDGID *Thin Forged Cutter Wheel*



★★★ *Faster* pipe threading with *Less work* ★★★

RIDGID *No. 65R has a fool-proof workholder you set to size instantly*

Just turn the pipe size on the cam plate to the arrow, put the threader on the pipe, tighten one screw—and start threading. No bushings. It's an instant, mistake-proof workholder. Setting chasers to thread 1", 1¼", 1½" or 2" pipe takes only 10 seconds — no extra chasers to waste time; one high speed steel set cuts clean perfect threads on all 4 sizes, drip threads, short nipples, over and under size pipe—so easily you can turn it with your little finger. A rugged all-steel and malleable alloy die stock, with drop-forged hardened steel cam plates. It pays you *now especially* to try this time-and-work-saver RIDGID No. 65R at your Supply House... today!



All RIDGID Pipe Tools are sold only through Supply Houses

RIDGID

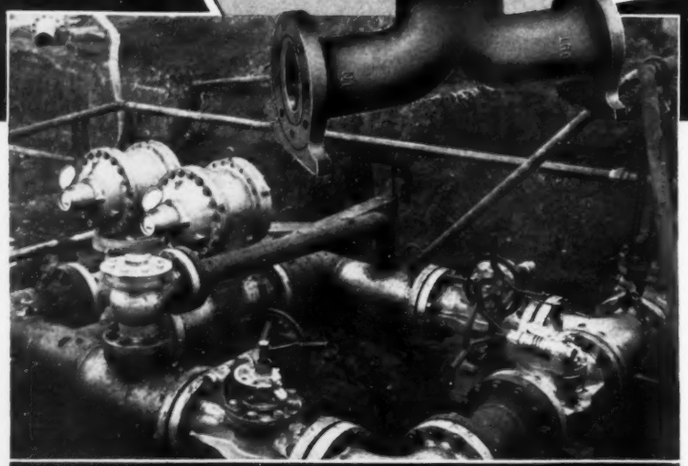
Pipe Wrenches, Cutters, Threaders, Vises

THE RIDGE TOOL COMPANY
ELYRIA, OHIO, U.S.A.

Work-Saver Tools for America's Big Job in 1942

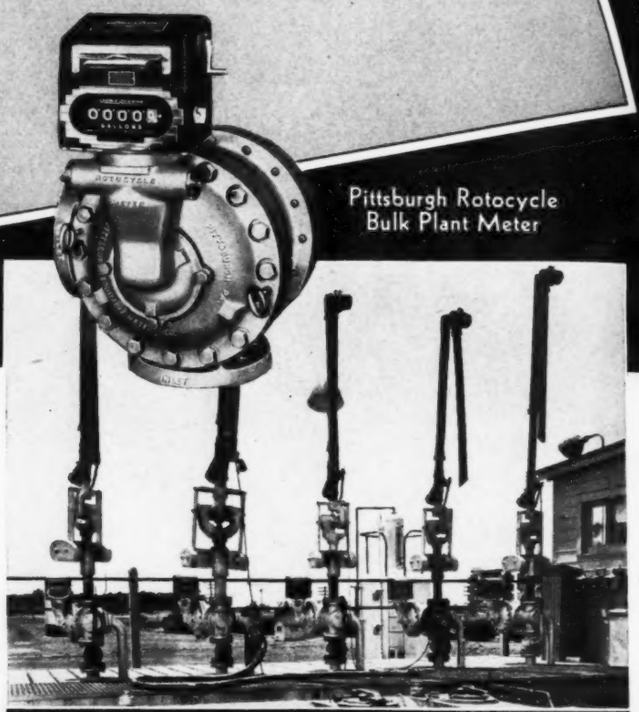
SENTINELS
on the Nation's Pipe Lines

Pittsburgh Rotocycle Pipe Line Meter



Pittsburgh Rotocycle Meters on Pipe Line Controlled by Nordstrom Valves.

Pittsburgh Rotocycle Bulk Plant Meter



Pittsburgh Rotocycle Meters on Nordstrom Valve Controlled Lines at Pipe Line Terminal.

PITTSBURGH ROTOCYCLE METERS

STANDING guard at every input and dispersal point, Pittsburgh Rotocycle Meters are successfully accounting for the gallonage transported through many of the Nation's largest pipe lines.

The Rotocycle was engineered primarily for pipe line service. It is a positive displacement meter consisting entirely of free running, rotating parts. Since there is no reciprocating action, it will operate accurately and stand up under the continual shocks and strains imposed by pipe line pumping. It is self-cleaning, with sturdy, oversize working parts made from the best materials.

Rotocycle Meters, in a complete range of sizes and types, are available to handle every pipe line or pipe line terminal measurement requirement. Operating engineers are invited to write for descriptive literature.

PITTSBURGH EQUITABLE METER COMPANY

NEW YORK · BROOKLYN · DES MOINES · MEMPHIS · OAKLAND · TULSA · CHICAGO · BOSTON

MERCO NORDSTROM VALVE COMPANY
Main Offices, Pittsburgh, Pa.
NATIONAL METER DIVISION, Brooklyn, N. Y.

KANSAS CITY · PHILADELPHIA · SAN FRANCISCO · LOS ANGELES · SEATTLE · HOUSTON · COLUMBIA · BUFFALO

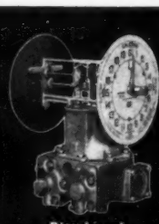
There's A Pittsburgh-National Meter for Every Type of Service

Pittsburgh Rotocycle for Bulk Plants, Tank Trucks

Pittsburgh Rotocycle for Pipe Line Service

Empire Streamline Oscillating Piston for Bulk Plants

Empire Oscillating Piston for Refinery and Industrial Services



Pittsburgh Reciprocating Piston for Service Station Pumps

Pittsburgh Reciprocating Piston for Tank Trucks, Bulk Plants

Pittsburgh Disc for Refinery and Industrial Services

FOR long rope life make certain your sheaves are of hard, wear-resisting metal. Soft sheaves wear rapidly. Once worn (and often corrugated) they both pinch the rope and develop a filing action. *Never put a new line on a worn, scored or corrugated sheave.* Select the proper sheave material, depending on the rope pressures encountered. Any American Cable engineer will gladly give you the benefit of his long experience.

And sheave diameters are very important, too. *If the sheave is too small, the sharp bend imposed upon the line induces high bending fatigue and early destruction.* To appreciate the importance of using correct diameters note that a 1" rope of 6 x 7 construction requires a 42" sheave while a 1" rope of 6 x 41 construction requires but an 18" sheave.

For average operations here is a table setting forth the proper minimum sheave diameters for ropes of varying constructions:

for 6 x 7 Construction	42 times diameter of rope
for 6 x 19 Seale Construction	34 times diameter of rope
for 6 x 16 Filler Wire Construction	30 times diameter of rope
for Flattened Strand (Type B & G)	30 times diameter of rope
for 8 x 19 Seale Construction	26 times diameter of rope
for 6 x 19 Filler Wire	26 times diameter of rope
for 6 x 22 Filler Wire	23 times diameter of rope
for 8 x 19 Warrington	21 times diameter of rope
for 8 x 19 Filler Wire	21 times diameter of rope
for 6 x 37 Seale	18 times diameter of rope
for 6 x 41	18 times diameter of rope

Paying attention to your sheaves pays dividends in longer rope wear, less trouble and steadier drilling. Specifying **TRU-LAY PREFORMED** pays dividends in the same way. Consult your nearest American Cable wire rope engineer. All American Cable ropes made of Improved Plow Steel are identified by the Emerald Strand.

AMERICAN CABLE DIVISION • WILKES-BARRE • PENNSYLVANIA

BRANCH OFFICES AND DISTRIBUTORS IN ALL OIL FIELD CENTERS

AMERICAN CHAIN & CABLE COMPANY, Inc.

BRIDGEPORT • CONNECTICUT

ESSENTIAL PRODUCTS ... AMERICAN CABLE Wire Rope, TRU-STOP Emergency Brakes, TRU-LAY Control Cables, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Iron Castings, CAMPBELL Cutting Machines, FORD Hoists and Trolleys, HAZARD Wire Rope, Yacht Rigging, Aircraft Control Cables, MANLEY Auto Service Equipment, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Electric Steel Castings, WRIGHT Hoists, Cranes, Presses ... *In Business for Your Safety*

NIMBLE FINGERS

"OPEN HOLE CALIPERS"